

Appendix G – Water Supply/Water Appropriation Supporting Documents

- Email from Mike Appelwick, October 1, 2012
- Email from ArcelorMittal, November 20, 2014
- Email from City of Virginia, November 21, 2014
- TH 53 Relocation Alternative E-1A Reinforced Soil Slope (RSS) Construction Option Water Management Study (HDR, 2014)
- Laurentian Divide Figure
- Summary of Existing Water Appropriation Permits and Intake Locations within Study Area

Haase, Rachel

From: Mike Appelwick <MAppelwick@nettechnical.com>
Sent: Monday, October 01, 2012 12:07 PM
To: Brad Scott
Subject: RE: VA. PUC Scanned Document

Brad,

I was able to discuss this with the MDH the last Friday the Virginia treatment capability with the current processes at the water treatment plant. It is difficult to determine the plant's ability to remove turbidity without additional chemical treatment. That being said with the current available treatment practice in Virginia the turbidity threshold is estimated at 5 turbidity units with Total Organic Carbon (TOC) at a threshold of 2 mg/l. Currently Virginia requires no treatment for disinfection by-products due to our raw water TOC level being less than 2 mg/l. If the level were to rise above 2 mg/l, Virginia would be required to consider additional treatment options to comply with the disinfection by-products rule. Mike

From: Brad Scott [<mailto:Brad.Scott@lhbcorp.com>]
Sent: Tuesday, September 25, 2012 3:21 PM
To: Mike Appelwick
Subject: RE: VA. PUC Scanned Document

Thanks Mike.

You were also going to look into turbidity threshold levels for the water supply system.

Any information in that regard?

Thanks again, Brad

From: Mike Appelwick [<mailto:MAppelwick@nettechnical.com>]
Sent: Tuesday, September 25, 2012 1:39 PM
To: Brad Scott
Subject: FW: VA. PUC Scanned Document

Brad, I will send you the 2010 & 2011 MDH CCR when I receive them from Nancy. Mike

From: Rhonda Dolinsky
Sent: Tuesday, September 25, 2012 1:22 PM
To: Mike Appelwick
Subject: VA. PUC Scanned Document



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Haase, Rachel

From: Mekkes, Steven I. [<mailto:Steven.Mekkes@arcelormittal.com>]

Sent: Thursday, November 20, 2014 12:50 PM

To: Johnson, Andrew (DOT)

Subject: RE: Hwy 53 - background for turbidity correspondence

Andy,

ArcelorMittal Minorca Mine does not believe that potential turbidity generated from the construction project will have an impact on our water intake given the distance from the alignment.

Steve

Please note my new direct line: (218) 305-3376

Steven I. Mekkes | Sr. Engineer | Mine/Crushing

ArcelorMittal Minorca

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Haase, Rachel

From: Greg French [<mailto:gfrench@VPUC.COM>]

Sent: Friday, November 21, 2014 9:59 AM

To: Huston, Patrick (DOT); John Tourville (johnt@virginiamn.us); Bill Hennis (hennisb@virginiamn.us)

Cc: Johnson, Andrew (DOT); Mike Applewick (NTS)

Subject: RE: Hwy 53 - background for turbidity correspondence

Pat,

After discussions this morning with Mike Appelwick, NTS, we believe that because of separation distances, depth of our raw water intake, physical structure (contours) of the adjoining pits, and also knowing the road construction will be effectively controlled with erosion control best management practices (BMP's), we feel that our facility will not be impacted by additional turbidity due to construction. Our WTP has a turbidity removal control system in place, which could be modified if a slight increase in turbidity intake levels are seen.

Please let me know if you need any additional information.

Thank you,

Greg French, PE

General Manager

Virginia Public Utilities

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**TH 53 RELOCATION ALTERNATIVE E-1A
REINFORCED SOIL SLOPE (RSS)
CONSTRUCTION OPTION
WATER MANAGEMENT STUDY**

**Prepared for
Minnesota Department of Transportation**

S.P.6918-80 (TH 53)

TH 53 RELOCATION ALTERNATIVE E-1A REINFORCED SOIL SLOPE (RSS) WATER MANAGEMENT STUDY

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1. INTRODUCTION

The Minnesota Department of Transportation (MnDOT) is evaluating several alternatives and construction options as part of the Draft Environmental Impact Statement for the realignment of Trunk Highway 53 (TH53) in Virginia, Minnesota. One of these options, designated as Alternative E-1A reinforced soil slope (RSS) causeway/fill section (Alternative E-1A – RSS Option), extends across the inundated Rouchleau Mine Pit which is now a part of the Missabe Mountain Pit Lake¹. The project area is shown on Figure 1.

MnDOT contracted with HDR Engineering, Inc. (HDR) and Gale-Tec Engineering, Inc. (GTE) to provide professional services to evaluate the feasibility of, probable costs for, and issues associated with partial dewatering of the pit for construction of the Alternative E-1A – RSS Option. The effects of temporarily lowering the water level in the pit on existing water supply systems with intakes in the Rouchleau Pit were also investigated.

The Rouchleau Mine was formerly mined for iron-bearing ore. The pit was dewatered during mining operations and filled with groundwater after mining ceased in the early 1980s. The City of Virginia (Virginia Department of Public Utilities) currently obtains water from the abandoned pit for its municipal water supply through a 200 foot deep intake. The ArcelorMittal mine also pumps water from the pit to supplement the water in the Enterprise Pit, which it uses for its Minorca taconite plant operations. Water is also occasionally diverted from the pit to the Sauntry Creek system via the ArcelorMittal pumping facilities to augment Silver and Bailey Lakes in the City of Virginia.

The Alternative E-1A – RSS Option involves construction of a roadway embankment on a section of a ledge that served as a mine haul road during active mining. The surface of the ledge is submerged approximately 30 feet below the current (2013) water surface. In order for the construction of the new embankment to occur in dry conditions, the pit would need to be partially dewatered for a period of approximately 12 months (3 months initial drawdown and 9 months of maintenance dewatering). This would involve obtaining permits and constructing pumping and conveyance infrastructure to transfer the water from the pit to an appropriate receiving water body.

This report summarizes considerations that determine the feasibility of a range of ‘receiving water’ options for dewatering the pit, investigates the potential effects of dewatering on local water supply/groundwater systems, and provides concept-level design and cost information for two temporary dewatering system alternatives. Assessment of the environmental impacts of the options determined to be feasible by this study will be included in the Environmental Impact Statement documentation for the project.

2. SCOPE OF WORK

MnDOT contracted with HDR/GTE in October 2013 to conduct a study to evaluate temporary dewatering of the Rouchleau Pit to accommodate construction of the Alternative E-1A – RSS Option. The scope of work included:

- Data collection including a site visit to the Rouchleau Pit,

¹ The water body is referred to as the Missabe Mountain Pit Lake and the Rouchleau Pit in different sources. It will be referred to as the Rouchleau Pit throughout this report.

- Preparation of a summary of hydrology and hydrogeology of the Rouchleau pit and surrounding area
- Identification of potential dewatering discharge locations and hydraulic and permitting issues that determine their feasibility as ‘receiving waters’.
- Evaluation of the effects of temporary dewatering on local conditions including a review of the effects on water supply systems for the City of Virginia and the ArcelorMittal mine.
- Development of a concept-level design for a dewatering system including layout, operations and costs.

HDR developed a simple groundwater flow model to assist in the evaluation of the dewatering. The scope also included two stakeholder meetings in Virginia.

For the study, HDR relied on existing data from various sources. MnDOT and GTE provided information on the proposed alignment, construction dewatering requirements, proposed project schedule for the Alternative E-1A – RSS Option construction, and bathymetric data for the Rouchleau Pit. Existing information on historic pit water levels and water quality data were obtained from the City of Virginia. Well logs from water supply and monitoring wells were obtained from the County Well Index, the Cities of Virginia and Mountain Iron, and private well owners. ArcelorMittal and the City of Virginia provided dewatering and pumping operations data.

3. STUDY AREA DESCRIPTION

The Rouchleau Pit is located east of the City of Virginia, Minnesota on the Mesabi Iron Range (Figure 2). The region is characterized by iron ore mining activity with several active and inactive mines dominating the landscape around the City. The current Rouchleau Pit was formerly several separate mining pits that have since filled with water and become one water body at the current water level. From north to south, these former pits consisted of: the Columbia Pit, the Commodore Pit, the Missabe Mountain Pit, the Shaw-Moose Pit, the Rouchleau Pit, and the southern Rouchleau Extension, all of which were mined for iron ore from the late 1800s into the 1980s. The Rouchleau Pit and Rouchleau Extension were divided by a bedrock ledge which was used as a haul road during active mining. The bedrock ledge is currently covered with approximately 50 feet of mine dump material. When mining activity and dewatering ceased in the 1980s the water level in the pits rose, eventually submerging the ledge and mine fill. During September 2013, the water elevation in the pit was 1,305 feet above mean sea level (AMSL)^{2,3}. Measurements taken in August 2013 indicate that the top surface of the mine fill was approximately 30 feet below the surface water elevation, or at 1,275 feet.

The pit water level is affected by pumping by the City of Virginia for municipal water supply and by pumping by ArcelorMittal to maintain the water level in the nearby Enterprise Pit. Intake and pumping facilities are shown on Figure 2. Water level records from 1983 to 2012 show that the water surface elevation in the pit reached a maximum of 1,310.65 feet in May 2009 (NTS, 2013). In 2011 the City of Virginia pumped an average of 1,794 gallons per minute (gpm) from the Rouchleau Pit. ArcelorMittal pumped an average of 1,215 gpm from the Rouchleau Pit in 2012.

² All elevations in this report are referenced to mean sea level.

³ Water levels in the pit have been shown to fluctuate. Measurements taken in September 2013 indicate a water surface elevation of 1,305 ft. Measurements in May 2014 indicate a water surface elevation of 1,310 ft.

The Enterprise Pit is approximately 1,000 feet to the north of the Rouchleau Pit and is pumped by ArcelorMittal for potable and processing use at the Minorca taconite plant. On September 30, 2013, the water elevation in the Enterprise Pit was 1,312 feet.

Other mine pits exist around the Rouchleau Pit that are or have been dewatered by pumping. Active mine pits include the Cliffs Natural Resources-UTAC Pit approximately one mile to the southwest, which is dewatered at 2,000-2,700 gpm. U.S. Steel-Minntac currently dewateres at mine pits approximately two miles to the northwest. Mining operations at the Minorca Pit, approximately 0.5-mile to the northeast, ceased in 1993. The water elevation in the Minorca Pit in October 2012 was 1,468 feet, up from 1,401 feet in November 1998 (NTS, 2013).

The water level in the Rouchleau Pit has historically been influenced by pumping, either as part of mining operations or by the City of Virginia. As a result, there is limited information on the static water level of the aquifer in the vicinity of the Rouchleau Pit. Estimates between 1,340 feet (MnDOT, 2014) and 1,428 feet (HDR, 1997) have been cited. It is conceivable that if all pumping from the pit were to cease in the future the water level could rise to an elevation similar to that in the City of Virginia well, which was 1,396 feet in November 1996 and 1,428 feet in June 1982 (HDR, 1997). However, the ultimate water level in the pit will depend on dewatering activities in the Biwabik Formation by other mines in the area.

4. HYDROLOGY AND HYDROGEOLOGY OF THE STUDY AREA

4.1. GEOLOGY AND HYDROGEOLOGY

The Rouchleau Pit is located in the Mesabi Iron Range, an iron-rich area in northeastern Minnesota. To the north of the pit, the Giants Range Granite Formation rises to form a topographic high that creates the Laurentian Divide. South of the Giants Range, under a mantle of glacial drift is a sequence of bedrock units including the Virginia Argillite, the Biwabik Formation, the Pokegama Quartzite, and Archean-aged basement rocks including the Ely Greenstone. These units have been warped into a Z-shaped geologic feature known as the “Virginia horn” in the vicinity of the Rouchleau Pit, causing the contacts of the Biwabik Formation with the Pokegama Quartzite and Virginia Argillite to assume the same shape. At Virginia, these formations have been folded, trending north to south, rather than following the normal east-west trend of the Mesabi Range. The Biwabik Formation is the primary aquifer contributing groundwater flow into the Rouchleau Pit. A detailed description and map of the regional geology is included in the Hydrogeology Section of the Appendix.

The Biwabik formation is unconfined at the mine pits and groundwater levels in the aquifer are higher than the groundwater levels in the pits. Pits that are actively mined are pumped (dewatered) to control groundwater inflow. Well logs indicate the Biwabik Formation is 435 to 600 feet thick near the Rouchleau Pit and thickens to the southwest where it is 740 feet thick. The hydraulic conductivity of the Biwabik Formation is generally low and has reported to range from 0.0046 to 5 feet/day⁴ and from 0.33 to 6.6 feet/day⁵. Kanivetsky and Walton also give an aquifer storativity of about 10⁻⁵ to 10⁻³ for the Biwabik Formation. Well yields are typically low

⁴ HDR, 1997

⁵ Kanivetsky and Walton, 1979

except in places where the formation is locally fractured; in those locations it can yield up to 1,000 gallons per minute (gpm) to wells.

The effects of mine dewatering on groundwater levels appear to be localized to areas near the pits and appear not to have caused a wide-spread drawdown of groundwater levels in the formation. For example, a map in a previous study⁶ showing November 20, 1996 water levels indicates the water level in the Rouchleau Pit (1,216 feet) was 180 feet lower than the water level in the City of Virginia well (1,396 feet) installed only 3,000 feet from the pit.

4.2. WATER BALANCE

Groundwater inflow into the Rouchleau Pit was calculated previously in water balance studies by others. HDR reviewed the hydrologic model presented in the report “Source Water Protection: Virginia Public Water Supply System, Alternative Sources and Selection Criteria”⁷. That report documented an average groundwater inflow rate of 2,306 gpm into the Rouchleau Pit during the 2004-2012 timeframe; this includes pumping by the City of Virginia over the entire timeframe and ArcelorMittal pumping that started in 2008. The HDR study⁸ indicated a groundwater inflow rate of 2,135 gpm into the pit during the 1991-1995 timeframe, which included pumping by the City of Virginia into the water balance.

As part of the review, data in Appendix B from the NTS report⁹ was entered into a spreadsheet and the calculations were checked. Calculations performed for this study matched the results for groundwater volumes and rates based on the data given in the NTS study (average groundwater inflow rate of 2,306 gpm). The hydrologic model assumptions presented were considered reasonable given the information available.

As a supplemental check on the water balance completed for the City of Virginia, HDR used recent bathymetric data from the Rouchleau Pit to recalculate water volumes in the pit for specific water surface elevations. This information was used to compare how the groundwater volumes and rates would change compared to the original NTS hydrologic model. The result was an average groundwater rate of 2,416 gpm, which is comparable to the NTS model.

Based on the water balance review the NTS hydrologic model can be considered an adequate assessment of water balance for the Rouchleau Pit. The inflow rate of 2,416 gpm calculated using the bathymetric data for the pit is a refinement to the NTS assessment. Because there is no information available that indicates future changes in outflow rates or pumping conditions, a groundwater inflow rate of 2,416 gpm will be used as a basis for developing dewatering rates for the study.

4.3. GROUNDWATER MODEL

HDR developed a groundwater flow model to analyze the rate of groundwater inflow to the Rouchleau Pit and to estimate the decrease in localized groundwater levels outside of the pit that could result from the partial dewatering of the pit water level from 1,305 to 1,275 feet. The

⁶ HDR, 1997

⁷ NTS, 2013

⁸ HDR, 1997

⁹ NTS, 2013

model was developed using MODFLOW 2000¹⁰, a finite-difference groundwater flow model developed by the United States Geological Survey (USGS).

The model consists of an approximately 43 square mile rectangular grid. It includes the Rouchleau Pit in its northeast corner, and extends from the pit to the southwest in the general direction dip of the Biwabik Formation.

Lowering the pit level from 1,305 feet to 1,275 feet and maintaining it at the lower elevation for a period of several months will cause an increase in groundwater inflow to the pit and a depression of local groundwater levels, due to water flowing towards the pit during dewatering. The analysis shows that up to 3,400 gpm of additional groundwater inflow can be anticipated in the initial period following drawdown, reducing to an additional 2,100 gpm six to twelve months after drawdown, and then stabilizing at an additional 2,060 gpm if dewatering were to continue into the future, as shown in Table 4.1. A detailed description of the hydrogeology and groundwater modeling is included in the Appendix. Section 7.0 below describes the results of the assessment of dewatering impacts on local groundwater wells.

Table 4.1
Groundwater Inflow Rates During Dewatering

Time Since Start Of Dewatering	Additional Groundwater Inflow From Lowering Pit Water Level From Elevation 1,305 Feet to 1,275 Feet (gpm)
1 month	3,407
2 months	2,623
6 months	2,117
12 months	2,062

5. DEWATERING TRANSFER

5.1. WATER TRANSFER QUANTITY AND RATE

HDR obtained bathymetric survey data collected by MnDOT in the fall of 2013 to determine an approximate volume of water associated with a drop in water surface elevation from 1,305 feet to 1,275 feet. The data indicates that a drop of 30 feet in the Rouchleau Pit water level represents a total volume of approximately 2.65 billion gallons. The bathymetric data also shows that the natural separation of the majority of the former mine pit complex (the Columbia Pit, the Commodore Pit, the Missabe Mountain Pit, the Shaw-Moose Pit, the Rouchleau Pit, and the southern Rouchleau Extension) would not be revealed at the proposed elevation of 1,275 with the exception of the separation of the Rouchleau Pit and southern Rouchleau Pit Extension (See Figure 8). The total volume of 2.65 billion gallons would need to be pumped from the pit to reveal the proposed roadway base and allow construction under dry conditions. Maintenance

¹⁰ Harbaugh et al., 2000

pumping would be required to maintain the water surface elevation at 1,275 feet during a portion of the construction period. Calculation of the initial drawdown rate and maintenance dewatering rate is described below.

HDR understands that the construction window for the Alternative E-1A – RSS Option is a period of 17 months. A 3-month window for the initial drawdown was assumed to allow the remaining 14 months for roadway construction within the pit. Maintenance dewatering would continue through a portion of the 14-month roadway construction period.

Based on a total dewatering volume of 2.65 billion gallons, the rate required to drop the pit water level 30 feet in 3 months is approximately 20,450 gallons per minute (gpm) or 29.4 million gallons per day (MGD). This discharge rate was then increased by the maximum additional groundwater inflow induced by the dewatering, an additional 3,400 gpm. This resulted in an estimated initial drawdown discharge rate of or 23,850 gpm or 34.3 MGD.

The groundwater model shows that lowering the pit level and maintaining it at 30 feet below steady state conditions during construction would induce up to a maximum additional inflow of 3,400 gpm into the pit (i.e., the initial inflow rate in Table 4.1). This rate assumes that the City of Virginia and ArcelorMittal would continue to draw water from the pit during the construction period. However, as described in Section 8.2.2 the 30-foot drop in water level in the Rouchleau Pit would render the ArcelorMittal pumping system inoperable. The pumping rates should, therefore, be increased to reflect the rate normally withdrawn by ArcelorMittal. This would increase the initial dewatering rate and the maintenance rate by 2,000 gpm, ArcelorMittal's maximum permitted withdrawal rate, to a rate of 25,850 gpm.

Based on the schedule provided by MnDOT, the embankment will reach a height greater than the initial water surface elevation of 1,305 feet several months into construction. For the purposes of this report, it was assumed that dewatering operations would continue for 9 months after the initial 3-month drawdown period, for a total dewatering period of 12 months. It is possible that maintenance dewatering equipment could operate during the initial 3-month drawdown period to supplement withdrawals by the main drawdown pumps. It is also possible that maintenance dewatering could be discontinued earlier in the construction process to allow groundwater to re-inundate the mine pit as construction of the embankment progresses. A summary of the estimated dewatering rates is provided in Table 5.1. A concept to mitigate the effects of dewatering on ArcelorMittal and the supply to the Enterprise Pit and Sauntry Creek system is described in Section 6.1.

Table 5.1
Estimated Dewatering Rates for Rouchleau Pit

Period	Estimated Dewatering Rate (gpm)
Initial Drawdown Dewatering (3-months)	25,850
Maintenance Dewatering (9 months)	5,400*

* 5,400 is the maximum projected inflow rate during the maintenance dewatering period

5.2. TRANSFER WATER QUALITY

5.2.1. WATER QUALITY OF THE ROUCHLEAU PIT

Information on the quality of the Rouchleau Pit water was obtained from drinking water quality reports prepared by the Virginia Public Utilities as part of its water quality testing and monitoring program. This information is summarized in Table 8.1 as part of the evaluation of the effect of dewatering on the Virginia water intake and treatment system. As noted in Section 8.1, the overall quality of water in the Rouchleau Pit is good, with no identified impairments that would be a concern regarding transferring the water to other water bodies.

5.2.2. ASSESSMENT OF AQUATIC INVASIVE SPECIES

HDR conducted a preliminary review of the potential for aquatic invasive species (AIS) in the Rouchleau Pit to determine if AIS would present an issue when considering discharge from the dewatering operations. HDR reviewed the Minnesota Department of Natural Resource's (MnDNR) Designation of Infested Waters to assess the potential for AIS. Based on the review, no assessment of the presence/absence of AIS in the Rouchleau Pit by the MnDNR has occurred.

There is no public access to the Rouchleau Pit, which minimizes the likelihood of human transport of AIS to the pit, or presence of AIS in the water. The MnDNR's Designation of Infested Waters has listed nearby Gilbert Pit (Ore-be-gone Lake), which has a public boating access, as infested with Eurasian watermilfoil and zebra mussels. It is unlikely that a transfer of AIS/water from Gilbert Pit to the Rouchleau Pit has occurred. Any water removed from the Rouchleau Pit will likely not contain AIS, and as a result any receiving waters are not in danger of receiving AIS from the Rouchleau Pit.

5.3. DEWATERING TRANSFER LOCATIONS

Fifteen potential locations for the dewatering transfer were identified using aerial mapping data and with input from MnDOT, MnDNR, the Minnesota Pollution Control Agency (MPCA), the City of Virginia, Virginia Department of Public Utilities, ArcelorMittal, Cliffs Natural Resources and Minntac. The potential locations and distances from the Rouchleau Pit are summarized in Table 5.2 and shown on Figure 3. Each of the options was evaluated based on DNR staff assessment of the capacity of each water body to receive the dewatering transfer volumes and rates, potential permitting implications associated with a potential water transfer, and other noted considerations. Issues that were identified during the evaluation process that made transfer locations problematic are noted in bold in Table 5.2.

Table 5.2
Potential Dewatering Transfer Locations

Location	Description	Evaluation
Sauntry Creek system including Bailey and Silver Lakes	Sauntry Creek system supplemented with diversion from Rouchleau Pit via Enterprise Pit. Flows through channelized creek to Bailey and Silver Lakes in City of Virginia. Silver Lake outlet to East Two River to Mashkenode Lake.	Does not have capacity to receive initial drawdown volume or rate. Initial evaluation indicates system has capacity to receive 4,000 – 6,000 gpm maintenance dewatering. Water transfer would not be subject to water quality permitting. Recommendation: Option for maintenance dewatering transfer.
Enterprise Pit	Inundated pit approx. 0.25 miles north of Rouchleau Pit. Receives discharge from ArcelorMittal pump station in Rouchleau Pit. Intake provides water for ArcelorMittal Minorca Mine water supply system.	Capacity to receive initial dewatering unknown. Level fluctuations associated with large volume input could affect ArcelorMittal pumping operations. Has capacity to receive maintenance dewatering with option to divert to Sauntry Creek system. Purported hydraulic connection to Rouchleau Pit. Water transfer would not be subject to water quality permitting. Recommendation: Option for maintenance dewatering transfer.
Manganika Creek	Largely channelized system through south and east portions of City of Virginia. Receives Virginia stormwater discharge, Virginia POTW discharge, and UTAC dewatering discharge from Thunderbird North Pit.	Capacity to receive initial drawdown volume and rate is limited. Further study required to determine actual capacity and suitability to receive maintenance dewatering. Significant water quality concerns for downstream system associated with flushing Manganika system with increased flow. Recommendation: Not carried forward as option for water transfer.
Manganika Lake	158-acre lake approx. 2 miles southwest of Rouchleau Pit. Receives flow from Manganika Creek and UTAC dewatering operations. Discharges to East Two River via Manganika Creek.	Capacity to receive initial dewatering volume and rate is limited. Significant water quality concerns for downstream system associated with flushing Manganika system with increased flow. Recommendation: Not carried forward as option for water transfer.

Location	Description	Evaluation
East Two River	Inflow from Mashkenode Lake and Manganika Lake. Confluence with St. Louis River approximately 11 miles south of Mashkenode Lake (i.e., 14 miles south of Rouchleau Pit).	Capacity to receive initial drawdown volume and rate is limited. East Two River system requires further study to determine capacity to handle maintenance dewatering. Recommendation: Not carried forward as option for water transfer.
West Two River Reservoir	713-acre reservoir approx. 6 miles west of Rouchleau Pit. Inflow from Parkville Creek. Outlet to West Two River. West Two River's confluence with St. Louis River approx. 11 miles south of outlet. Serves as back-up water source for Minntac operations. Receives Minntac dewatering discharges.	Initial assessment shows reservoir has capacity to receive rate and volume from initial drawdown. Total inflow volume would result in increased outflow from reservoir to West Two River. Initial assessment of West Two River system shows capacity to accommodate increased flow during the drawdown period. Would be considered a water transfer and would not require water quality permitting. Recommendation: Option for initial drawdown transfer.
Pike River	Approx. 2.5 miles east of Rouchleau Pit. Flows north in Hudson Bay watershed.	Transfer of water from Rouchleau would constitute inter-basin transfer and would require agreement through Great Lakes Compact . Project schedule precludes requirements for compact negotiations. Recommendation: Not carried forward as option for water transfer.
UTAC Hull/Spruce Hill Pit complex	Inundated pits approx. 3.5 miles south of Rouchleau Pit.	Combined capacity of Hull and Spruce Hill pits thought to be adequate for initial discharge. Purported hydraulic connection with active UTAC Thunderbird North Pit to the north. Transfer of water from Rouchleau Pit could affect existing mining operations Recommendation: Not carried forward as option for water transfer.

Location	Description	Evaluation
UTAC South Pit	Inundated pit approx. 4 miles south of Rouchleau Pit south of Eveleth. Receives UTAC dewatering discharge. Discharges periodically to St. Louis River via Long Lake Creek to supplement flow for UTAC appropriation.	Based on initial assessment has capacity to receive initial discharge. Transfer of water into South Pit from Rouchleau Pit would affect UTAC NPDES permit for discharge to the St. Louis River. Any change in the make-up of the water ultimately discharged to the River would trigger major permit modification/permit re-issuance. Recommendation: Not carried forward as option for water transfer.
Ore-Be-Gone Lake	Inundated former mine pits near the City of Gilbert	Insufficient capacity to take volume from initial discharge. Purported to have hydraulic connection to Laurentian mine. Increase in volume may affect water level in Laurentian mine and may impact recreational features of lake. Recommendation: Not carried forward as option for water transfer.
Ely Lake	830 acre lake located approximately 2.5 miles southwest of Eveleth. Controlled outlet and connection to St. Mary's Lake.	Lake is highly developed. Transfer of large volume may affect lake property owners. Outlet may not have capacity to handle increased outflow. Recommendation: Not carried forward as option for water transfer.
Minntac Mountain Iron Pit	Inundated pit approx. 4 miles west of Rouchleau Pit in Mountain Iron. Likely has capacity to receive initial discharge Receives dewatering discharge from Minntac mine operations. Used as supply water for Minntac.	Water is considered part of Minntac facility. Transfer of water into Mountain Iron pit from Rouchleau Pit would affect Minntac NPDES permit. Would trigger major permit modification/permit re-issuance. Recommendation: Not carried forward as option for water transfer.
Minntac Tailings Basin Cell 2	Tailings basins approx. 6 miles northwest of Rouchleau Pit.	Has capacity to receive initial dewatering rate and volume. Would require permit action under existing Minntac NPDES permit. Interbasin transfer by Minntac allowed under Minnesota's baseline diversion. Recommendation: Option for initial drawdown transfer.

Location	Description	Evaluation
St. Louis River	Closest point approx. 10.5 miles south of Rouchleau Pit. Ultimately drains to Lake Superior.	<p>Closest discharge point 10.5 miles south of Rouchleau Pit along TH 53. Preliminary DNR assessment indicates that the river has capacity to receive rate and volume from initial drawdown and maintenance dewatering. Would be considered water transfer and would not require water quality permitting.</p> <p>Recommendation: Not carried forward as option for water transfer.</p>

As noted previously, the options for discharge of the Rouchleau Pit dewatering operations were analyzed for their capacity to receive the initial drawdown and/or maintenance dewatering water volume and rates, and the potential water appropriations and water quality permit requirements and implications.

Evaluation Results: Initial Drawdown Receiving Waters

Many of the options for the transfer of the initial drawdown water were eliminated due to their inability to accommodate either the total volume or the high flow rate associated with the 3-month period allocated for the initial dewatering. These include the Sauntry Creek system, Manganika Creek, Manganika Lake, Mashkenode Lake, East Two River and Ore-Be-Gone Lake. The UTAC Hull/Spruce Hill Pit complex and the Enterprise Pit were removed from consideration as options for the initial drawdown volume because of the potential for interference with mining operations. Two other options were removed from consideration because the proposed water transfer and introduction of a new water source could trigger major modification or re-issuance of an existing National Pollutant Discharge Elimination System (NPDES) permit. These included the Minntac Mountain Iron Pit, and the UTAC South Pit. The Pike River was eliminated for either discharge because it would require negotiation of an inter-basin transfer agreement under the Great Lakes-St. Lawrence River Basin Water Resources Compact (Great Lakes Compact) for a new water use, which would not fit within the project schedule. Ely Lake was removed from consideration due to uncertainty of the ability of the outlet to handle the increased volume and outflows, and the risk of water level rise on a highly developed shoreline. The St. Louis River is not recommended at this time because there are other potentially viable alternatives closer to the Rouchleau Pit (described below) that appear to be feasible.

The options that are recommended for further consideration for the initial dewatering period are the West Two River Reservoir and the Minntac Tailings Basin Cell 2.

The West Two River Reservoir is located approximately 5.5 miles west of Rouchleau Pit. It was created in 1963 by US Steel to be used as a water source for mining operations and processing. The reservoir has natural inlets and receives discharges from Minntac dewatering operations. There are two outlets from the reservoir to West Two River, including a fixed-head dam and a siphon-controlled outlet. The siphon, which was included as part of the permit that allowed establishment of the reservoir, provides a minimum flow of 3 cubic feet per second to West Two River to maintain a minimum base flow below the reservoir. West Two River eventually

flows into the St. Louis River.

Initial analysis of the West Two River Reservoir shows that it has capacity to take a large portion of the volume associated with the initial drawdown transfer. Depending on water level and conditions at the time of the transfer, the additional volume will be accommodated by available storage within the reservoir, and any excess will discharge over the dam, increasing the flow in West Two River. Assessment by MnDNR of historic streamflow conditions in West Two River indicates that the river could handle the temporary increase in flow that would result. MnDNR has also indicated that due to the temporary nature of any increase in outflow from the reservoir, stream erosion is not an issue. Transfer of water from the Rouchleau Pit to West Two River reservoir would require a new water appropriation permit (issued to MnDOT). This dewatering option would be considered a water transfer and would not be subject to MPCA water quality permitting, provided that there was no intervening commercial or industrial use of the water and no pollutants were introduced during transfer of the water.

The Minntac Tailings Basin Cell 2 is located approximately six miles northwest of the Rouchleau Pit. Water and tailings are discharged into the tailings basin. There is no discharge outlet from the tailings basin. Under current operations, water from the basin is re-circulated to the plant to be used as mine process water.

According to US Steel, the Minntac Tailings basin has capacity to receive the volume associated with the initial drawdown. Although transfer from the Rouchleau Pit to the tailings basin would, constitute an inter-basin transfer under the Great Lakes Compact, the diversion would be covered by the existing baseline diversion. The transfer would likely require an administrative amendment to US Steel Minntac's permit (1963-0846) to include the Rouchleau Pit as a water source. A new appropriation permit would not be required. Cell 2 is part of an existing NPDES permit. A transfer of water from the Rouchleau Pit to this option would require an NPDES permitting action, however, the quality of water to be transferred would be expected to improve the water quality within Minntac's basin. MnDOT conducted water quality testing of the Rouchleau Pit water to document current conditions in March 2014 and May 2014. Results are summarized in Table 5.3.

Evaluation Results: Maintenance Dewatering Receiving Waters

The recommended receiving waters for the maintenance dewatering period are the Enterprise Pit and the Sauntry Creek system, given their ability to handle the maintenance flow rate and the potential benefit of being able to mitigate for drawdown impacts, as discussed in more detail in Section 8.2. The Enterprise Pit is located approximately one quarter mile north of the Rouchleau Pit. It is an inundated former mine pit with no natural outlet. ArcelorMittal has an appropriation permit to pump water from the Enterprise Pit by for use at Minorca mine. ArcelorMittal also has an appropriation permit to pump water from the Rouchleau Pit into the Enterprise Pit to maintain the water level in the Enterprise Pit. The existing ArcelorMittal withdrawal system that pumps water from Rouchleau Pit into the Enterprise Pit has the ability to divert flow into the Sauntry Creek system. This diversion is used periodically to augment Bailey and Silver Lakes in the City of Virginia.

Table 5.3
Rouchleau Pit Water Quality Test Results

Parameter	Units	Results (3/13/14)	Results (5/29/14)
Mercury, Low Level	ng/L	ND	8.2
Aluminum	µg/L	ND	ND
Calcium	mg/L	53.5	49.8
Iron	µg/L	ND	ND
Magnesium	mg/L	38.6	36.6
Manganese	µg/L	ND	ND
Sodium	mg/L	17.4	16.6
Total Hardness by 2340B	mg/L	293	275
Field pH	Std. Units	7.51	7.84
Field Temperature	deg C	3.1	10.8
Field Specific Conductance	µmohs/cm	624.3	564.0
Oxygen, Dissolved	mg/L	10.23	11.83
Turbidity	NTU	0.0	0.0
Alkalinity, Total as CaCO ₃	mg/L	206	199
Alkalinity, Bicarbonate (CaCO ₃)	mg/L	206	199
Specific Conductance	µmohs/cm	661	588
Total Dissolved Solids	mg/L	334	325
pH, Electrometric	Std. Units	7.8	8.2
Chloride	mg/L	36.8	33.5
Fluoride	mg/L	0.16	0.12
Sulfate	mg/L	56.5	49.7
Nitrate as N	mg/L	ND	ND
Nitrogen, Ammonia	mg/L	ND	ND

Notes: ND = None detected

5.4. PERMITTING

This section describes anticipated permitting for the dewatering location options recommended for further consideration.

5.4.1. APPROPRIATIONS

Water use, including transfers of water and dewatering for construction, are managed by the MnDNR through the water appropriation permit program. The MnDNR can include conditions in the permit requirements, if deemed necessary, to minimize and/or mitigate potential impacts. The MnDNR is authorized to issue long-term appropriation permits for individual uses that exceed daily and annual use volumes, and has a General Permit (1997-0005) which authorizes temporary appropriations including dewatering for construction activities. Water uses that meet the requirements for an Individual Appropriation Permit (i.e., if volumes exceed the General Permit conditions) must complete an application for review from MnDNR. Minnesota statutes allow local units of government 30 days to review appropriation permit applications.

A transfer of water from the Rouchleau Pit to accommodate construction of the Alternative E-1A – RSS Option would require either a new MnDNR individual water appropriation permit, a temporary construction dewatering permit, or a modification to an existing MnDNR water appropriation permit, depending on the receiving water.

A transfer of water from the Rouchleau Pit to the West Two River Reservoir would likely require a new MnDNR water appropriation permit. In this case, MnDOT would apply for the new permit and would be required to complete an application for review from MnDNR. Minnesota statutes allow local units of government 30 days to review appropriation permit applications. Although there is no formal public review period for appropriation permits information and documentation submitted with the application form is public information.

A transfer from the Rouchleau Pit to the Minntac Tailings Basin Cell 2 would likely require an administrative amendment to US Steel Minntac's permit (1963-0846) to include the Rouchleau Pit as a water source. A new appropriation permit would not be required. Once the EIS documentation was deemed adequate, an administrative amendment could be pursued by Minntac.

A temporary MnDNR water appropriation permit would be required for transferring water from the Rouchleau Pit to the Enterprise Pit. MnDOT would apply for the temporary construction dewatering permit through MnDNR.

5.4.2. WATER QUALITY

The MPCA regulates the discharge of wastewater to receiving waters of the state and operation of wastewater disposal systems through its NPDES/SDS water quality permitting program. It does not regulate transfers of water, as defined by federal law, from one water body to another that does not involve an intervening commercial or industrial use or the introduction of pollutants. Determination of whether or not NPDES/SDS permits would be required by MPCA for the transfer of water from the Rouchleau Pit to any receiving water body considered will depend on a number of factors. These include water quality comparisons, water management practices, concentration and loading determinations,

whether there is an intervening use of the water or pollutants are added during the transfer, and whether or not the receiving water is part of an existing NPDES/SDS permit.

Initial assessment by the MPCA indicates that the quality of the Rouchleau Pit water is good, and water quality concerns are not anticipated for any of the potential receiving waters retained for further consideration (Enterprise Pit/Sauntry Creek system, West Two River Reservoir and Minntac Tailings Basin Cell 2). Dewatering activities that occur during the initial drawdown period would likely be considered a water transfer and would not require an MPCA NPDES/SDS permit. Maintenance dewatering during construction would likely be considered a transfer, and not a discharge, as long as the quality of the water is not adversely affected by construction activities. The ultimate determination of water quality permitting requirements will depend on the impact of construction activities on the quality of the Rouchleau Pit water, and how effectively potential impacts are minimized or mitigated.

The Enterprise Pit and the West Two River Reservoir are not part of an existing NPDES/SDS permits and could receive a water transfer without specific NPDES/SDS permitting action. Minntac's Tailings Basin Cell 2 is part of an existing NPDES/SDS permit. Therefore, a transfer of water from the Rouchleau Pit would require an NPDES/SDS permitting action. However, the quality of water to be transferred is expected to improve the water quality within Minntac's basin. MnDOT conducted water quality testing in March and May 2014. Results are summarized in Table 5.3, above.

5.4.3. ST. LAWRENCE – GREAT LAKES COMPACT

The Great Lakes Compact prohibits diversion of water from the Great Lakes Basin. The compact was adopted in 2005 and signed into law in 2008. Within five years of the compact adoption, a list of existing withdrawals, diversions, and consumptive uses were submitted by each state to establish a baseline for determining new or increased withdrawals, diversions, and consumptive uses. Within the list submitted by the State of Minnesota was US Steel Minntac's water appropriation permit 1963-0846 which authorizes a volume of 24.1 million gallons per day (8.797 billion gallons per year (BGY))¹¹ as part of the baseline diversions.

Under the Minntac Cell 2 option, movement of water from the Rouchleau Pit to the Minntac Tailings Basin would constitute an inter-basin transfer. The Rouchleau Pit lies within the St. Louis River watershed, which is part of the St. Lawrence – Great Lakes basin. The Minntac Cell 2 lies within the Little Fork watershed, which is part of the Hudson Bay basin.

A transfer of water from the Rouchleau Pit to the Minntac Tailings basin would constitute a transfer of water out of the Lake Superior Watershed, and would normally require regional review and exemption through the Great Lakes Compact process. However, because water transferred out of the Lake Superior watershed by Minntac was identified as part of Minnesota's baseline diversion, and is below the permitted 8.797 billion gallons per year, MnDNR officials have indicated that a transfer from the Rouchleau Pit to the Minntac Tailings Basin Cell 2 would be allowed under the current baseline diversion.

¹¹ Minnesota DNR Appropriation Permit #1963-0846

Implementation of this option would require an administrative amendment to Minntac's existing water appropriation permit to include the Rouchleau Pit as a water source. A new appropriation permit would not be required. Once the EIS documentation was deemed adequate, an administrative amendment could be pursued by Minntac.

5.4.4. STORMWATER

The construction of the proposed Alternative E-1A –RSS Option will require a NPDES/SDS Construction Stormwater activity permit, which may be covered under the State's Construction Stormwater General Permit. As part of the application process, the owner and operator must create a stormwater pollution prevention plan (SWPPP) that explains how stormwater will be controlled to prevent introduction of sediment and other pollutants transported by runoff. The control of runoff from construction that occurs during the dewatering period will factor into the MPCA's review and determination that the dewatering operations can be classified as a water transfer, which does not require a NPDES discharge permit.

6. CONCEPTUAL-LEVEL DESIGN OF DEWATERING SYSTEM

Conceptual layouts and preliminary costs for the dewatering system were completed for both the West Two River Reservoir and Minntac Tailing Basin Cell 2 options for the initial drawdown transfer, and for the Enterprise Pit/Sauntry Creek option for the maintenance dewatering transfer.

6.1. CONCEPTUAL LAYOUT AND OPERATIONS OF DEWATERING SYSTEM

In configuring the layouts for the dewatering system, consideration was given to the location and capacity of receiving waters, feasibility of pipeline routes, flexibility and redundancy of operations, and maintenance of existing water uses. MnDOT developed preliminary pipeline routes for the dewatering options, described in greater detail in Sections 6.1.1 through 6.1.3.

The dewatering system configurations include two separate installations. Both installations would consist of temporary diesel-powered pumping stations and associated suction and discharge piping. A larger system was designed to operate during the initial 3-month drawdown period. Options for transfer from the Rouchleau Pit to West Two River Reservoir and to Minntac Tailings Basin Cell 2 were developed for comparison. Pumps and pipeline sizes for these alternatives were based on the dewatering rate of 25,850 gpm to accommodate transfer of the entire drawdown volume to the receiving water during the initial 3-month drawdown period. The smaller maintenance dewatering system was configured to pump the estimated maintenance dewatering rate of 5,400 gpm from the Rouchleau Pit to the Enterprise Pit/Sauntry Creek system for a 12-month period, including the 3-month initial drawdown period, and 9-month maintenance dewatering period. The systems were designed with the ability to operate together during the initial 3-month drawdown period to provide flexibility in discharge routing and flow rate, and redundancy of operation. Once the initial drawdown is accomplished, the larger pump station and pipelines could be taken out of service.

6.1.1 TRANSFER TO WEST TWO RIVER RESERVOIR

West Two River Reservoir is located approximately 5.5 miles west of the Rouchleau Pit. The dewatering system that would transfer water from the Rouchleau Pit to the West Two River Reservoir would include a bank of six 4,500 gpm pumps and three 30-inch HDPE

discharge pipes. The pumps would be installed in the southwest corner of the Rouchleau Pit near the current water surface.

Discharge piping would be routed above ground, primarily in existing road and railroad right-of-way. The pipeline would leave the Alternative E-1A – RSS Option project area crossing under existing US 53 via existing bridges near 2nd Avenue and would follow US 53 right-of-way to US 169. The pipe would extend along the south side of US 169 to an existing power line corridor just north of the reservoir. The pipe would follow the power line corridor south to the reservoir. At the discharge point, flow dissipation would be installed to minimize erosion. The route is shown in Figure 4.

The total length of the discharge route is approximately 5.7 miles. The elevation along this route varies from 1,275 feet at the low water level to a maximum elevation of 1,465 feet approximately 3.25 miles into the route. Total head conditions assumed for this route are estimated at 314 feet.

6.1.2 TRANSFER TO MINNTAC TAILINGS BASIN CELL 2

The Minntac Tailings Basin Cell 2 is located approximately six miles northwest of the Rouchleau Pit. The dewatering system that would transfer water from the Rouchleau Pit to Cell 2 of the Minntac Tailings basin would be installed in the northwest end of the Rouchleau Pit and include a bank of six 4,500 gpm pumps located near the current water surface. Three 30-inch HDPE discharge pipes would be routed above-ground from the Rouchleau Pit. At approximately 2.5 miles into the route, the flow would be boosted through another bank of six 4,500 gpm pumps and then routed through three 30-inch HDPE pipes to the discharge point. At the discharge flow dissipation would be installed to reduce energy and minimize erosion.

Discharge piping would be routed above ground, primarily in existing road and railroad right-of-way, although easement through several private parcels would be required along the route near the Rouchleau Pit. From the Rouchleau Pit, several potential route configurations have been identified to take the pipeline across the ArcelorMittal property. These include existing mine access roads. Other options for the route on the east side of TH 53 could include segments along a power line corridor, existing access roads, TH 53 right-of-way, or railroad right-of-way. On the west side of TH 53 where the power line meets the Minntac mine road at the tailings basin, the pipe would follow the east side of the mine road, then cross under the mine road to the west side near Cell 1. The pipe would follow the edge of Cell 1, until it reaches Cell 2. The routes (and variations) are shown in Figure 5.

The total length of the main discharge route used to determine costs is 8.9 miles. The elevation along this route varies from 1,275 feet at the low water level to a maximum elevation of 1,855 feet approximately 5.5 miles into the route. Total head conditions for this route are estimated at 766 feet.

6.1.3 TRANSFER TO ENTERPRISE PIT/SAUNTRY CREEK

The Enterprise Pit is located immediately north of the Rouchleau Pit. The dewatering system that would transfer water from the Rouchleau Pit to the Enterprise Pit would be installed on the north end of the Rouchleau Pit. It would be designed to discharge approximately 5,400 gpm to the Enterprise Pit with an option to divert flow to the Sauntry

Creek system. This configuration would help control the water level in the Enterprise Pit, mitigate the effects of dewatering the Rouchleau Pit on the existing ArcelorMittal water management operations (see Section 8.2), and maintain the ability to augment water flow to Bailey and Silver Lakes in the City of Virginia. Three 4,500 gpm pumps would be located near the Rouchleau Pit water surface. The use of three pumps provides flexibility in operation and redundancy in the event one pump were taken out of service during the pumping period.

Discharge piping would be routed above ground, paralleling the existing ArcelorMittal discharge piping and make use of the existing diversion structure, if possible. The total length of the discharge route is 1,320 feet. The route is shown on both Figures 4 and 5. The land along the proposed route is owned by RGGGS Land and Minerals, Ltd. At the discharge point, flow dissipation would be installed to reduce discharge energy and minimize erosion.

The maintenance dewatering system would be in place for the 3-month initial dewatering period and be kept in place for an estimated 9 months following initial drawdown. It is possible that the dewatering activities could be discontinued and groundwater allowed to recharge the pit earlier as construction of the embankment progresses.

6.2. COST ESTIMATES

Cost estimates were developed for two dewatering alternatives. The first includes the option to transfer water from the initial drawdown of the Rouchleau Pit to the West Two River Reservoir and discharge the maintenance dewatering system to the Enterprise Pit/Sauntry Creek system. The second includes the option to transfer water from the initial drawdown of the Rouchleau Pit to Minntac Tailings Basin Cell 2, with maintenance dewatering discharged to the Enterprise Pit/Sauntry Creek system.

Cost estimates for both options include the set-up of two separate temporary pumping stations, pump rental, suction and discharge pipe rental, and diesel fuel costs. Mobilization for each option was estimated at 4 percent of construction costs. An additional 15 percent contingency was included in the preliminary design estimate to cover undeveloped design details. Costs for part-time (12-hour) pump and pipeline monitoring during the duration of the dewatering operation were included.

6.2.1. WEST TWO RIVER RESERVOIR, ENTERPRISE PIT/SAUNTRY CREEK OPTION

A preliminary opinion of probable costs for this option totals \$15.2 million. Under this option, seven 4,500 gpm drawdown pumps (6 operating and 1 spare) and three 4,500 gpm maintenance pumps (2 operating and 1 spare) were included in the estimate. The estimate includes a 3-month initial drawdown period and 9 months of maintenance pumping. It was assumed that the maintenance pumping system would be operational for the 3-month drawdown period in addition to the 9-month maintenance dewatering period. It was also assumed that after the initial 3-month drawdown period, the drawdown pumps could be taken out of service. A detailed breakdown of the costs is included in Table 6.1. An estimated monthly cost of \$135,000 for maintenance dewatering, which includes pump rental, fuel, and pump watch costs, is also listed.

Table 6.1
Costs - West Two River Reservoir, Enterprise Pit/Sauntry Creek Option

Item No.	Item Description	Basis	Cost
1	Mobilization (4%)	1 @ \$507,000	\$507,000
2	Drawdown Pump Set-Up (7 pumps)	7 @ \$160,000/pump	\$1,120,000
3	Maintenance Pump Set-Up (3 pumps)	3 @ \$140,000/pump	\$420,000
4	Drawdown Pump Rental (7 pumps for 3 months)	(7 x 3 mos) @ \$9,500/mo	\$199,500
5	Maintenance Pump Rental (3 pumps for 12 months)	(3 x 12 mos) @ \$8,000/mo	\$288,000
6	20" Suction Pipe (9 runs)	(9 x 40 ft) @ \$55/ft	\$19,800
7	30" SDR11 HDPE Discharge Piping (3 runs)	(3 x 30,100 ft) @ \$95/ft	\$8,578,500
8	18" SDR 17 HDPE Discharge Piping (1 run)	(1 x 1,320 ft) @ \$50/ft	\$66,000
9	Fuel – Bulk Diesel (6 pumps for 3 months)	162,000 gal @ \$4/gal	\$648,000
10	Fuel – Bulk Diesel (2 pumps for 12 months)	109,500 gal @ \$4/gal	\$438,000
11	Pump Watch Labor and Expenses	12 months @ \$75,000/mo	\$900,000
Subtotal			13,185,000
Undeveloped Design Details (15%)			\$1,978,000
Total			\$15,163,000
<i>Cost per month for maintenance dewatering period (included in the Total above)</i>			<i>\$135,000/month</i>

6.2.3. MINNTAC TAILINGS BASIN CELL 2, ENTERPRISE PIT/SAUNTRY CREEK OPTION

A preliminary opinion of probable costs for this option totals \$23.1 million. This option includes the installation of seven drawdown pumps (6 operating and 1 spare), six booster pumps (6 operating) and three maintenance pumps (2 operating and 1 spare). The estimate assumes a 3-month initial drawdown period and 12 months of maintenance dewatering. After the initial 3-month drawdown period, the seven drawdown pumps could be taken out of service. A detailed breakdown of the costs is included in Table 6.2. An estimated monthly cost of \$135,000 for maintenance dewatering is also listed.

Table 6.2
Costs – Minntac Tailings Basin Cell 2, Enterprise Pit/Sauntry Creek Option

Item No.	Item Description	Basis	Cost
1	Mobilization (4%)	1 @ \$771,000	\$771,000
2	Drawdown Pump Set-Up (13 pumps)	13 @ \$160,000/pump	\$2,080,000
3	Maintenance Pump Set-Up (3 pumps)	3 @ \$140,000/pump	\$420,000
4	Drawdown Pump Rental (13 pumps for 3 months)	(13 x 3 mos) @ \$9,500/mo	\$370,500
5	Maintenance Pump Rental (3 pumps for 12 months)	(3 x 12 mos) @ \$8,000/mo	\$288,000
6	20" Suction Pipe (9 runs)	(9 x 40 ft) @ \$55/ft	\$19,800
7	30" SDR11 HDPE Discharge Piping (3 runs)	(3 x 47,000 ft) @ \$95/ft	\$13,395,000
8	18" SDR 17 HDPE Discharge Piping (1 run)	(1 x 1,320 ft) @ \$50/ft	\$66,000
9	Fuel – Bulk Diesel (12 pumps for 3 months)	324,000 gal @ \$4/gal	\$1,296,000
10	Fuel – Bulk Diesel (2 pumps for 12 months)	109,500 gal @ \$4/gal	\$438,000
11	Pump Watch Labor and Expenses	12 months @ \$75,000/mo	\$900,000
Subtotal			\$20,044,000
Undeveloped Design Details (15%)			\$3,007,000
Total			\$23,051,000
<i>Cost per month for maintenance dewatering period (included in the Total above)</i>			<i>\$135,000/month</i>

6.3. ANALYSIS OF COSTS - EXTENDED DEWATERING TIME PERIODS

An analysis was performed to determine the effect of several different dewatering schedules and discharge scenarios on estimated dewatering system costs. The cost estimates presented in the previous section assumed a time period of 3 months for the initial drawdown, and 9 additional months of maintenance dewatering. Additional analyses compared these costs with costs associated with a 12-month initial drawdown period with transfer to the West Two River Reservoir and Minntac Cell 2 transfer locations. Under both scenarios, the maintenance dewatering would be directed to the Enterprise Pit/Sauntry Creek system.

Another set of analyses examined the costs associated with transferring both the initial dewatering volume and maintenance flow to the Sauntry Creek system via the Enterprise Pit. A range of costs was computed for several flow rate and time period scenarios for transfer of the initial drawdown volume to the Enterprise Pit/Sauntry Creek system (3,800 gpm for 24 months, 7,400 gpm for 10 months and 8,900 gpm for 8 months). The flow rate and duration for the maintenance period for all options were kept at 5,400 gpm and 12 months to maintain consistency between these and the West Two River Reservoir and Minntac Cell 2 options.

Cost estimates for these scenarios included similar assumptions as those computed in the previous section. Estimates include the set-up of temporary pumping stations, pump rental, suction and discharge pipe rental, and diesel fuel costs. Mobilization for each option was estimated at 4 percent of construction costs. An additional 15 percent contingency was included in the preliminary design estimate to cover undeveloped design details. Costs for part-time (12-hour) pump and pipeline monitoring during the duration of the dewatering operation were included.

Costs associated with the extended dewatering periods, and the transfer of the drawdown volume to the Sauntry Creek system via the Enterprise Pit at various flow rates are summarized in Table 6.3 below. Options shown in the first two rows represent the 3-month initial drawdown and 12-month total dewatering period scenarios detailed in the previous section. These are shown for comparison.

The analysis shows that extending the initial drawdown period to 12 months would reduce the drawdown pumping rate to 6,200 gpm and would reduce costs by approximately \$5 million (33 percent) for the West Two River Reservoir option and approximately \$9.5 million (40 percent) for the Minntac Cell 2 option.

Costs range from \$4.14 million to \$5.95 million for the three pumping systems that would transfer the entire drawdown volume into the Enterprise Pit/Sauntry Creek system. The time periods range from 20 months for a system that divert flow at an estimated rate of 8,900 gpm to 36 months for a system that would divert flow at a rate of 3,800 gpm. For all three of these options, maintenance pumping would also be pumped to the Enterprise Pit/Sauntry Creek system.

Table 6.3
Alternative Cost Analyses

Drawdown Transfer Option (Initial/Maintenance)	Initial Draw-down Period (months)	Initial Draw-down Period Flow Rate (gpm)	Maintenance Dewatering Period (months)	Total Dewatering Period (months)	Cost (millions)
West Two River Reservoir, Enterprise Pit/ Sauntry Creek	3	25,850	9	12	\$15.2
Minntac Cell 2, Enterprise Pit/ Sauntry Creek	3	25,850	9	12	\$23.1
West Two River Reservoir, Enterprise Pit/ Sauntry Creek	12	6,200	12	24	\$10.14
Minntac Cell 2, Enterprise Pit/ Sauntry Creek	12	6,200	12	24	\$13.65
Enterprise Pit/ Sauntry Creek	24	3,800	12	36	\$5.95
Enterprise Pit/ Sauntry Creek	10	7,400	12	22	\$4.51
Enterprise Pit/ Sauntry Creek	8	8,900	12	20	\$4.14

6.4. ANALYSIS OF COSTS - 2014 WATER LEVEL IN THE ROUCHLEAU PIT

The water level in the Rouchleau Pit was measured at 1,310 by MnDOT in May 2014. To determine the potential impact of higher water on the estimated costs for dewatering, HDR recomputed the water volume and dewatering rate that would be required to lower the pit water level to 1,275 feet in the same 3-month drawdown period assumed in the initial cost analysis.

The bathymetric survey data collected by MnDOT in the fall of 2013 was used to revise the water volume associated with a drop in water surface elevation from 1,310 feet to 1,275 feet. The volume was calculated to be 3.17 billion gallons, an increase of 513 million gallons over the volume associated with an initial water surface elevation of 1,305 feet. Adjusting for the

maximum additional groundwater inflow induced by the dewatering, and projected pumping from the pit, a revised dewatering rate of or 29,825 gpm or 36.9 MGD was calculated. This is an increase of 3,975 gpm over the dewatering rate associated with the pit water surface elevation of 1,305 feet. Dewatering volumes and rates associated with the two initial water surface elevations are shown in Table 6.4.

Table 6.4
Estimated Dewatering Rates for the Rouchleau Pit

	Initial Elevation 1,305 feet	Initial Elevation 1,310 feet
Volume to dewater to Elevation 1,275 (billion gallons)	2.65	3.17
Dewatering Rate ⁽¹⁾ (gpm)	25,850	29,825

(1) Dewatering rate adjusted to include maximum groundwater inflow of 3,400 gpm and exclude 2,000 gpm withdrawal by ArcelorMittal.

The conceptual design and cost estimates for the West Two Rivers and Minntac Cell 2 discharge options developed in the previous sections assumed the installation banks of pumps feeding into three 30-inch pipes. Six pumps and 1 spare were included in the cost estimates for both options. The Minntac Cell 2 option included additional banks of booster pumps along the pipe route to meet the higher head conditions associated with this alignment. The increase in pumping rate to 29,825 gpm would require the pumps to operate at a higher rate, and would require an additional pump for the West Two Rivers option. This increased the costs from \$15.2 million to \$15.5 million an increase of approximately \$300,000. For the Minntac Cell 2 option, the pumps would operate at a higher rate, and three additional booster pumps would be required to meet the head conditions. An additional pump would not be required at the main pump station. These changes would result increase the estimated costs from \$23.1 million to \$24.1 million, an increase of approximately \$1 million. Costs associated with the higher Rouchleau Pit water surface elevation are shown in Table 6.5.

Table 6.5
Costs – Higher Initial Water Surface Elevation in the Rouchleau Pit

Drawdown Transfer Option (Initial, Maintenance)	Cost (millions) Water Level @ 1,305 ft.	Cost (millions) Water Level @ 1,310 ft.
West Two Rivers Reservoir, Enterprise Pit/Sauntry Creek	\$15.2	\$15.5
Minntac Cell 2, Enterprise Pit/Sauntry Creek	\$23.1	\$24.1

7. DEWATERING EFFECTS ON LOCAL GROUNDWATER

Numerous domestic and non-domestic water supply wells are present in the area. Most of these wells are installed in the glacial drift and Virginia Argillite formations. Comparatively few wells are installed in the Biwabik Formation in this area. Table 7.1 contains a list of water supply wells that are installed in the Biwabik Formation within approximately one mile of the pit. These wells are also shown on Figure 6 in the Appendix.

The list includes one well installed by the City of Virginia near the steam plant on the south side of Silver Lake that is open to the Biwabik Formation from 118 to 450 feet; this well is not in use. The City of Mountain Iron has two wells open to the Biwabik Formation from 160 to 375 feet and 160 to 425 feet, each pumping about 114 gpm annually (Walsh, 2009). These wells are about four miles west of the Rouchleau Pit. The intake sections of these wells are below the depth of dewatering proposed for the TH53 Alternative E-1A – RSS Option.

Table 7.1
Biwabik Formation Water Supply Wells

Township-Range-Section	Unique Well ID	Name	Use	Depth (ft)	Bottom Elevation (ft MSL)
58-17-08	476180	Virginia 1*	Municipal	288	n/a
58-17-08	476181	Virginia 2*	Municipal	287	n/a
58-17-10	534407	St. Louis Co. Health Dept.	Public Supply	308	1,357
58-17-10	626721	St. Louis Co. Solid Waste	Industrial	366	1,330
58-17-16	239254	Johnson, Raymond	Domestic	173	1,460
58-17-22	668979	A Plus Auto Salvage	Commercial	325	1,263

(Source: Minnesota County Well Index)

* Ground surface elevations for Virginia intake wells not available.

The effects of temporarily lowering the water level in the pit were evaluated as part of the groundwater modeling exercise. Simulated groundwater levels indicate that the effects of dewatering will be limited to the immediate area around the pit. Local groundwater levels in the Biwabik Formation will decline approximately 10 to 20 feet within one mile of the pit, with the effects decreasing with distance from the pit. The dewatering anticipated for the project and resulting impact on groundwater levels is not expected to cause an issue with operation of wells in the Biwabik Formation within 1 mile of the Rouchleau Pit. The 10 to 20 foot decline in the groundwater levels in the area is not expected to drop water levels to within the intake areas of the existing wells. It is also important to note that the pit has historically had much lower water elevations than 1,275 feet (for example, the pit water surface elevation was approximately 1,240 feet in 2000) with no reported interference with local wells.

The water level in the Rouchleau Pit has historically been influenced by pumping, either as part of mining operations, or by the City of Virginia. If all pumping were to cease in the pit, the pit water

level could equilibrate to an elevation similar to that in the nearby City of Virginia power plant well (unused), which is installed in the Biwabik Formation. Recorded groundwater elevations in the well include 1,396 feet in November 1996 and 1,428 feet in June 1982 (HDR, 1997). The ultimate water level in the pit would depend on dewatering activities in the Biwabik Formation by other mines in the area.

7.1. PIT RECHARGE AFTER CONSTRUCTION

Once construction activities are completed and the dewatering systems are shut down, the water level in the Rouchleau Pit will eventually rise back to its normal operating starting elevation near 1,305 feet provided no new stresses (e.g., increased City pumping) are introduced. The time to refill the pit from 1,275 feet to 1,305 feet was estimated using two different methods. The results of the analyses are shown in Table 7.2.

The first method used the results of the groundwater model and assumed that the aquifer was 'ideal', where the pit recovery rate mimics the pit drawdown rate. In this case the pit recharges at 3,400 gpm initially, and slows to 2,060 gpm after about 7 months as the aquifer recovers and the hydraulic gradient flattens. Using this method, about 70 percent of the dewatered pit volume would be recovered after 19 months, which roughly corresponds to a pit water surface elevation of 1,296 feet; 100 percent recovery would occur in approximately 28 months.

The second method to estimate pit recharge used Darcy's Law (an empirical relationship used to calculate flow through an aquifer) and pit bathymetry, along with starting and ending hydraulic gradients estimated from the drawdown contours in the groundwater model. A starting (dewatered condition) hydraulic gradient of 0.008, and ending (refilled condition) hydraulic gradient of 0.006 were estimated, and Darcy's Law was then used to calculate the time to refill the pit water surface in 1-foot increments. Using this method, about 70 percent of the dewatered pit volume was recovered after 22 months and 100 percent recovery occurred in approximately 33 months.

All calculations assumed that the City of Virginia and ArcelorMittal maintain their current pumping rates. The recovery of the pit water level is directly related to pumping withdrawals; increases in pumping would slow the recovery of the pit water level, while decreases in pumping would hasten recovery.

Table 7.2
Rouchleau Pit Water Level Recovery

Pit Water Surface Elevation (ft MSL)	Time Since End of Dewatering (months)	
	'Ideal' Aquifer Recharge Method	Darcy Recharge Method
1,275	0	0
1,280	4	4
1,285	8	9
1,290	13	14
1,295	18	20
1,300	23	26
1,305	28	33

8. DEWATERING EFFECTS ON EXISTING ROUCHLEAU PIT WATER USERS

There are two water intakes located in the Rouchleau Pit. The City of Virginia uses the Rouchleau Pit as its raw water source for the City's drinking water system and to supply cooling water to the Virginia Public Utilities' power plant. ArcelorMittal pumps water out of the northeast end of the Rouchleau Pit to supplement the water storage in the Enterprise Pit that provides potable and process water for the Minorca Mine operations. ArcelorMittal also diverts a portion of the flow to supplement the Sauntry Creek system, which flows into Bailey Lake and Silver Lake in the City of Virginia.

Consideration was given to the water availability, water quality, operations, and permitting effects of the temporary dewatering. The existing intake facilities and the water surface elevation at the current level (1,305 feet) and the proposed elevation of 1,275 feet are shown on Figure 6.

8.1. CITY OF VIRGINIA

8.1.1. DESCRIPTION OF WATER SUPPLY SYSTEM

Virginia Public Utilities provides potable water to approximately 13,000 people and businesses in Virginia and a portion of Mountain Iron¹². Source water is obtained from the Rouchleau Pit, which is located within the Virginia City limits approximately one-half mile east of the city's water treatment plant. The Virginia water intake consists of a horizontal drift into the pit that feeds two vertical wells, from which raw water is pumped to the

¹² NTS, Water Treatment Facility

treatment plant.¹³ (See Figure 6) The pumping station is located on City-owned land on the west side of the pit, near Chestnut Street

The water treatment plant, constructed in 2001, can treat a maximum of five million gallons per day (MGD) and has a treated water reservoir with a storage capacity of 4.5 million gallons (MG). Average demand is approximately 1.7 MGD; maximum daily demand is 3.1 MGD. The conventional water treatment plant includes coagulation, flocculation, sedimentation, gravity filtration, fluoridation, corrosion control, and disinfection (Figure 7).¹⁴ The treatment plant is producing water that meets the federal and state drinking water standards.¹⁵

8.1.2. HISTORIC WATER SYSTEM SUSCEPTIBILITY

The Minnesota Department of Health, with the help of Virginia Public Utilities, completed a Source Water Assessment for the City of Virginia in 2003 in accordance with the 1996 Amendments to the Safe Drinking Water Act. The assessment included the geologic setting of the Rouchleau iron ore pit and concluded that very little surface water runoff enters the water body. The large volume of water in the Rouchleau Pit helps to attenuate contaminant concentration and also affects the movement of contaminants to the public water supply intake. However, MDH has determined the susceptibility of the Rouchleau Pit to be high because there are no practical means of preventing all potential contaminant releases into the surface water.

The Source Water Assessment identified the contaminants of greatest concern to the Virginia water supply to include: manganese; molybdenum and other metals; arsenic; bromine; fluoride; oils; fuels; solvents; sedimentation; microorganisms; and turbidity.¹⁶ The city's water plant has effectively treated this source water to meet or exceed safe drinking water standards.¹⁷

8.1.3. WATER QUALITY

Table 8.1 lists water quality data collected on November 27, 2012¹⁸ and is considered to be representative of the City's raw water quality.

In terms of water quality, there is no indication that changes in water treatment will be necessary during the dewatering activities. An increase in turbidity and suspended solids could be observed during this time resulting from disruption of settled materials in the pit. However, the physical plant appears to provide the appropriate water treatment equipment to meet increases in turbidity and suspended solids especially given the plant's design capacity of 5 MGD compared with current average and maximum day water demands of 1.7 MGD and 3.1 MGD, respectively. The excess capacity provides flexibility for operators to make appropriate adjustments.

¹³ Source Water Assessment, 2003

¹⁴ NTS, Water Treatment Facility

¹⁵ Consumer Confidence Report, 2012

¹⁶ Source Water Assessment, 2003

¹⁷ Source Water Assessment, 2003

¹⁸ Pace Analytical, 2012

Table 8.1
Source Water Quality for Virginia, Mn

Parameter	Measured Concentration	Maximum Contaminant Limit (MCL)	Secondary Maximum Contaminant Limit (SMCL)
Physical			
pH	7.5	n/a	6.5 – 8.5
Specific Conductance	690 µmhos/cm	n/a	n/a
Total Dissolved Solids	369 mg/L	n/a	500 mg/L
Total Suspended Solids	1.2 mg/L	99.9% removal of particles 3µm and larger	n/a
Turbidity	n/a	Turbidity <1.0 NTU 100% of samples and ≤0.3 NTU in 95% of samples	n/a
Cations			
Aluminum	ND	n/a	n/a
Calcium	59.1 mg/L	n/a	n/a
Hardness, Calcium	148 mg/L as CaCO ₃	n/a	n/a
Hardness, Total	318 mg/L as CaCO ₃	n/a	n/a
Iron	ND	n/a	0.3 mg/L
Magnesium	41.3 mg/L	n/a	n/a
Manganese	62.4 µg/L	n/a	50 µg/L
Sodium	15.9 mg/L	n/a	250 mg/L
Ammonia	ND	n/a	n/a
Anions			
Alkalinity, Total	239 mg/L as CaCO ₃	n/a	n/a
Alkalinity, Bicarbonate	239 mg/L as CaCO ₃	n/a	n/a
Chloride	33.0 mg/L	n/a	250 mg/L
Fluoride	0.17 mg/L	4.0 mg/L	2.0 mg/L
Nitrate	0.13 mg/L as N	10 mg/L as N	n/a
Nitrite	ND	1 mg/L as N	n/a
Sulfate	54.9 mg/L	n/a	250 mg/L
Microbiological			
Total Coliforms	Present	5.0%	n/a
E. coli Bacteria	Absent	Present	n/a

Notes: n/a indicates no standard is established. ND = None detected

8.1.4. OPERATIONS

Lowering the water level in the Rouchleau Pit will have minimal effects on the raw water pumps that supply the Virginia Public Utilities' water treatment plant. The submerged intake for the raw water pumps is at elevation 1,117 feet. With a 30 foot drawdown of the pit, the water surface elevation in the pit is projected to be as low as 1,275 feet during the earliest part of construction of the embankment. Although this does not violate the minimum water elevation of 1,123 feet established at the time of construction of the pumphouse¹⁹ it will change the head conditions under which the pumps operate.

The raw water pumping system is made up of two 8-stage vertical turbine pumps designed for 2,000 gpm each at 350 to 360 feet of total dynamic head. The increase in total head resulting from the lowered pit depth will shift the operating point on the pump curve. With higher head conditions, the pump capacity would be reduced from 2,000 gpm to 1,800 gpm and the efficiency is lowered from 83 percent to approximately 81 percent. Although the energy required per gallon of water pumped increases slightly the overall horsepower requirement for the pumps does not change. The reduced capacity of the pumps may require slightly longer pump run time, but the effects are not substantial and should not affect the utility's ability to effectively treat and deliver water.

8.1.5. PERMITTING

The City of Virginia has secured a water appropriation permit (MnDNR Permit #1984-2037) to withdraw water from the Rouchleau Pit at a rate not to exceed 4,000 gpm. The permit stipulates a maximum annual withdrawal of 1 billion gallons, combined from two intakes. The temporary lowering of the pit water level for construction dewatering should not affect the City's appropriation permit.

8.1.6. ASSESSMENT OF EFFECT ON CITY OF VIRGINIA WATER SUPPLY

The overall effects of dewatering the Rouchleau Pit on the Virginia water supply system are minimal. In terms of water quality, there is no indication that changes in the water treatment will be necessary during the dewatering activities. The existing treatment plant has excess capacity which allows operational flexibility and the ability to adjust process controls and flow rates. Lowering the pit level will alter the raw water pumping conditions, but the effects on pump operation and energy use are not substantial, especially given the short-term nature of the impacts.

8.2. ARCELORMITTAL

8.2.1. DESCRIPTION OF WATER SUPPLY SYSTEM

ArcelorMittal operates a water intake barge located in the northeast corner of the Rouchleau Pit. This barge houses one submersible pump which conveys water through a 16-inch diameter steel/plastic pipeline that runs north from the pit up the ridge to Sauntry Creek. Since its installation in 2008, the barge in the Rouchleau Pit has operated at water elevations between 1,301 feet and 1,310 feet.

¹⁹ NTS, 2013

At Sauntry Creek a diversion structure and valve configuration splits the flow. During regular operations, the flow is directed to the Enterprise Pit to supplement the water storage in that pit for use at the Minorca plant. Flow can also be directed into Sauntry Creek to deliver water to the City of Virginia for the maintenance of Bailey Lake and Silver Lake. The pumping systems and access roads to the facilities are located on land leased from RGGSC Corporation.

ArcelorMittal operates a barge-mounted pumping system in Enterprise Pit which pumps water from the Enterprise Pit to its Minorca Mine taconite plant for potable and process-related uses, approximately 1.7 miles northeast of the pit. The water intake barge houses three submersible pumps and is stationed in the northwest corner of the Enterprise Pit. Water is pumped from the Enterprise Pit through a 16-inch diameter steel pipeline that runs to the Minorca plant. Since 2008, the barge has operated at water elevations between 1,305 feet and 1,314 feet.

8.2.2. OPERATIONS

Lowering the water level in the Rouchleau Pit would affect the operation of ArcelorMittal's water intake barge. Based on lake bathymetry²⁰ and the configuration of the barge system, a 30-foot drop in water level would render ArcelorMittal's Rouchleau Pit pumping system inoperable. (See Figure 8 showing the Rouchleau Pit at proposed elevation of 1,275 feet.) This would limit ArcelorMittal's ability to control the water level in the Enterprise Pit and potentially disrupt flow to the Sauntry Creek system that is periodically supplemented with Rouchleau Pit water to feed the City lakes. However, this effect can be mitigated, as discussed in Section 8.2.4 below.

8.2.3. PERMITTING

In 1973, the operator of the Minorca Mine secured a water appropriation permit (MnDNR Permit #1973-5095) to pump water from the Enterprise Pit. The permit is now in ArcelorMittal's name, and includes a maximum annual allowance of 2.476 billion gallons, with no imposed limit on pumping rate. ArcelorMittal uses the water for potable and process supply at the Minorca taconite plant.

In 2008, ArcelorMittal secured a water appropriation permit to pump water from the Rouchleau Pit (MnDNR Permit #2008-0216). Water from the Rouchleau Pit is pumped to maintain the water level in the Enterprise Pit. Water can also be diverted to the City of Virginia through a diversion system to assist with the maintenance of Bailey Lake and Silver Lake as discussed above. Permit #2008-0216 stipulates a maximum annual withdrawal of 903.9 million gallons from the Rouchleau Pit, a maximum pumping rate of 2,000 gpm, and a minimum water elevation of 1,280 feet has been incorporated into the permit to protect the City's water supply.

8.2.4. ASSESSMENT OF EFFECT ON ARCELORMITTAL WATER SUPPLY

Dewatering the Rouchleau Pit by 30 feet would have a substantial impact on the ArcelorMittal mine water supply system, primarily in terms of available water quantity. A

²⁰ MnDOT, 2013

30-foot drop in water level would render the existing ArcelorMittal pumping system in the Rouchleau Pit inoperable. Once the water level falls below 1,280 feet, ArcelorMittal is no longer permitted to pump from the Rouchleau Pit. The ramifications of this are the inability to maintain the water level in the Enterprise Pit and deliver water to the City of Virginia lakes via Sauntry Creek. If the water level in the Enterprise Pit drops below approximately 1,305 feet, the water intake barge would need to be moved and/or reconfigured.

As noted in Section 6, the effects on ArcelorMittal's water supply could be minimized/mitigated by using the dewatering system to maintain the water level in the Enterprise Pit. ArcelorMittal's barge in the Rouchleau Pit would be allowed to go dry during construction in this scenario. Water from dewatering could also be routed to Sauntry Creek to maintain the ability to augment Bailey and Silver Lakes in the City of Virginia.

Without the mitigation measures described in Section 6, the ArcelorMittal mine would need to submit an amendment to their appropriation permit requesting an allowance to continue pumping below the specified elevation of 1,280 feet during the temporary construction period. ArcelorMittal may also need to negotiate its lease with RGGGS Corporation allowing for relocation of the pumping system and access to the site.

9. CONCLUSIONS

This study explored requirements and considerations associated with dewatering the Rouchleau Pit to allow dry construction of the TH 53 Alternative E-1A – RSS Option. The study included an investigation of the effects of temporary dewatering on local systems, identified water bodies that could potentially receive the transfer from Rouchleau Pit, and provided concept-level design and cost information for a temporary dewatering system.

The majority of the potential receiving waters assessed in this study were not carried forward for further study as a result of the short schedule for construction associated with the Alternative E-1A – RSS Option, which factored into the allowance of a 3-month period for the initial drawdown. The relatively compressed schedule for the initial drawdown resulted in a high discharge rate, which limited the receiving water options.

Three options were identified that could potentially receive the water transfer from the Rouchleau Pit. These include the West Two River Reservoir and the Minntac Tailings Basin Cell 2 as options to receive the dewatering transfer during the initial drawdown period, and the Enterprise Pit/Sauntry Creek system as the best option to receive water from the Rouchleau Pit during the maintenance dewatering period. Costs associated with these options were estimated to range from \$15.2 million to \$23.1 million.

Temporary dewatering of the Rouchleau Pit is not projected to have a substantial effect on the City of Virginia's water supply. The raw water intake is sufficiently deep within the Rouchleau Pit and the water treatment process used by Virginia Public Utilities is capable of handling small fluctuations in raw water quality that may be encountered during construction. The major impact of the temporary dewatering will be on the existing Rouchleau Pit pumping system used by ArcelorMittal. A 30 foot drop in the water level will render the existing system inoperable. However, the concept developed for the maintenance dewatering system will mitigate the effects on this water user.

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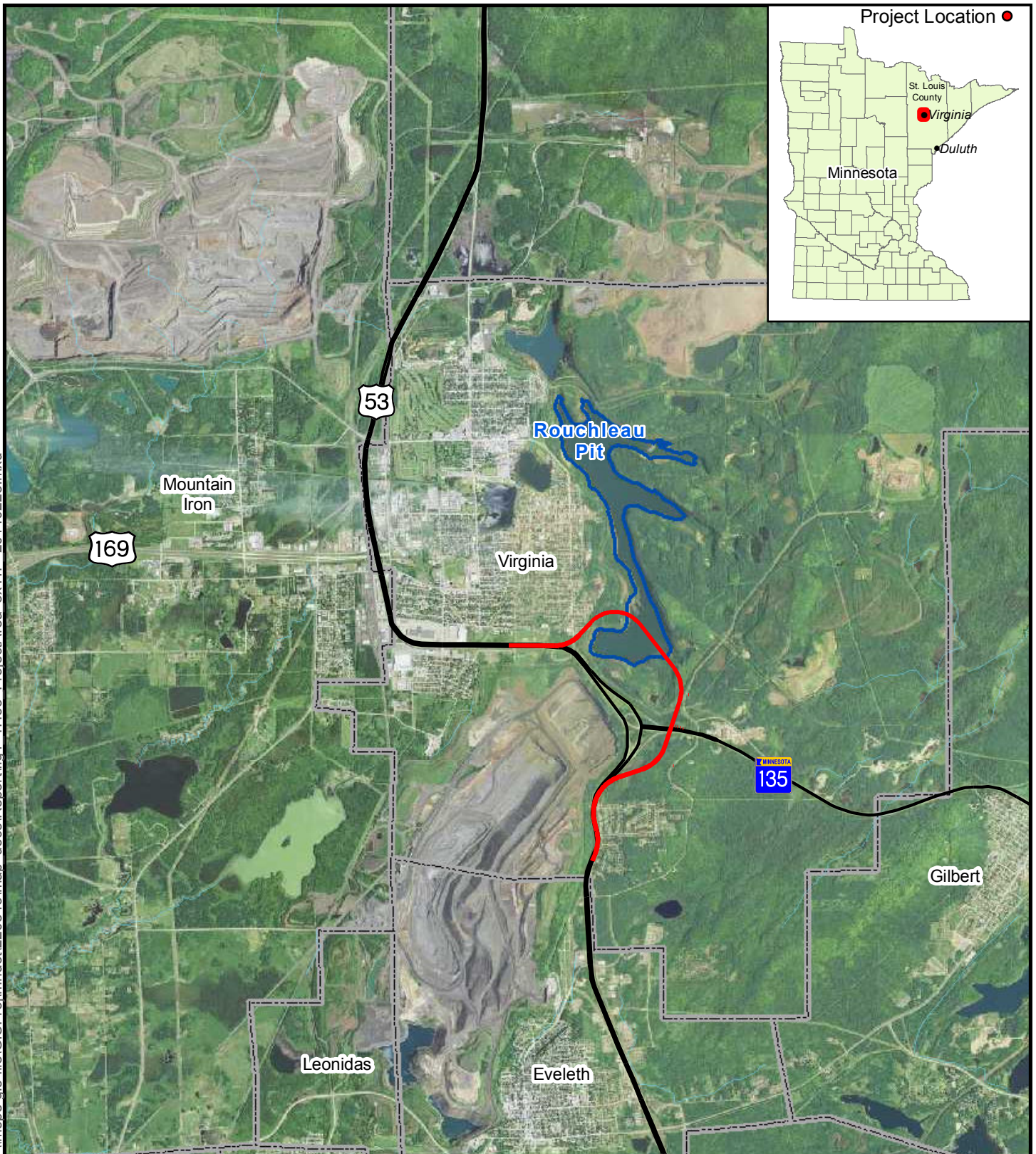
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FIGURES

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9/22/2014



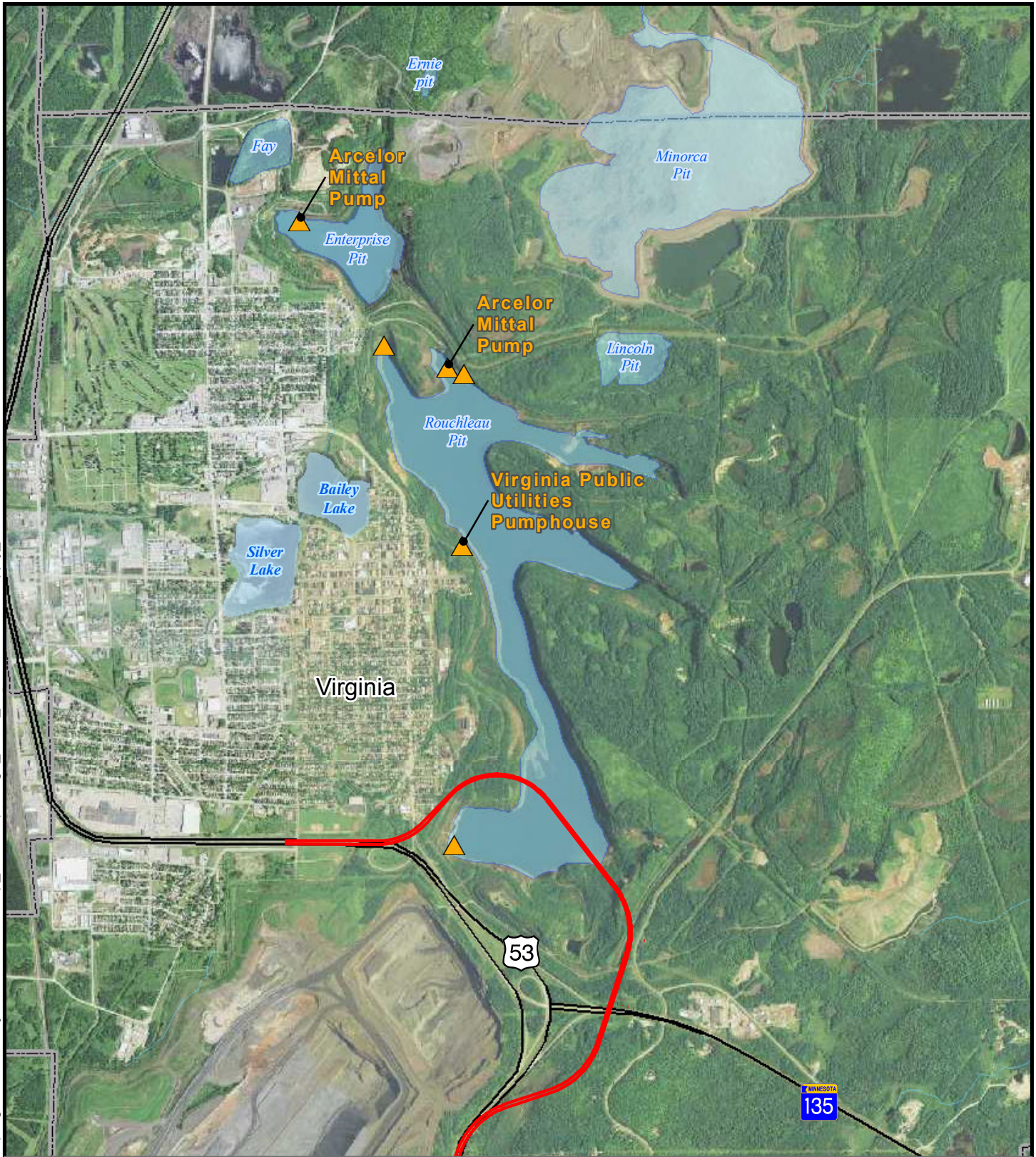
- E-1A Alignment
- Rouchleau Pit

Figure 1: Project Area

TH 53 Alternative E-1A - RSS Option
Water Management Study



0 0.25 0.5
Miles





-  Pumping station
-  E-1A Alignment

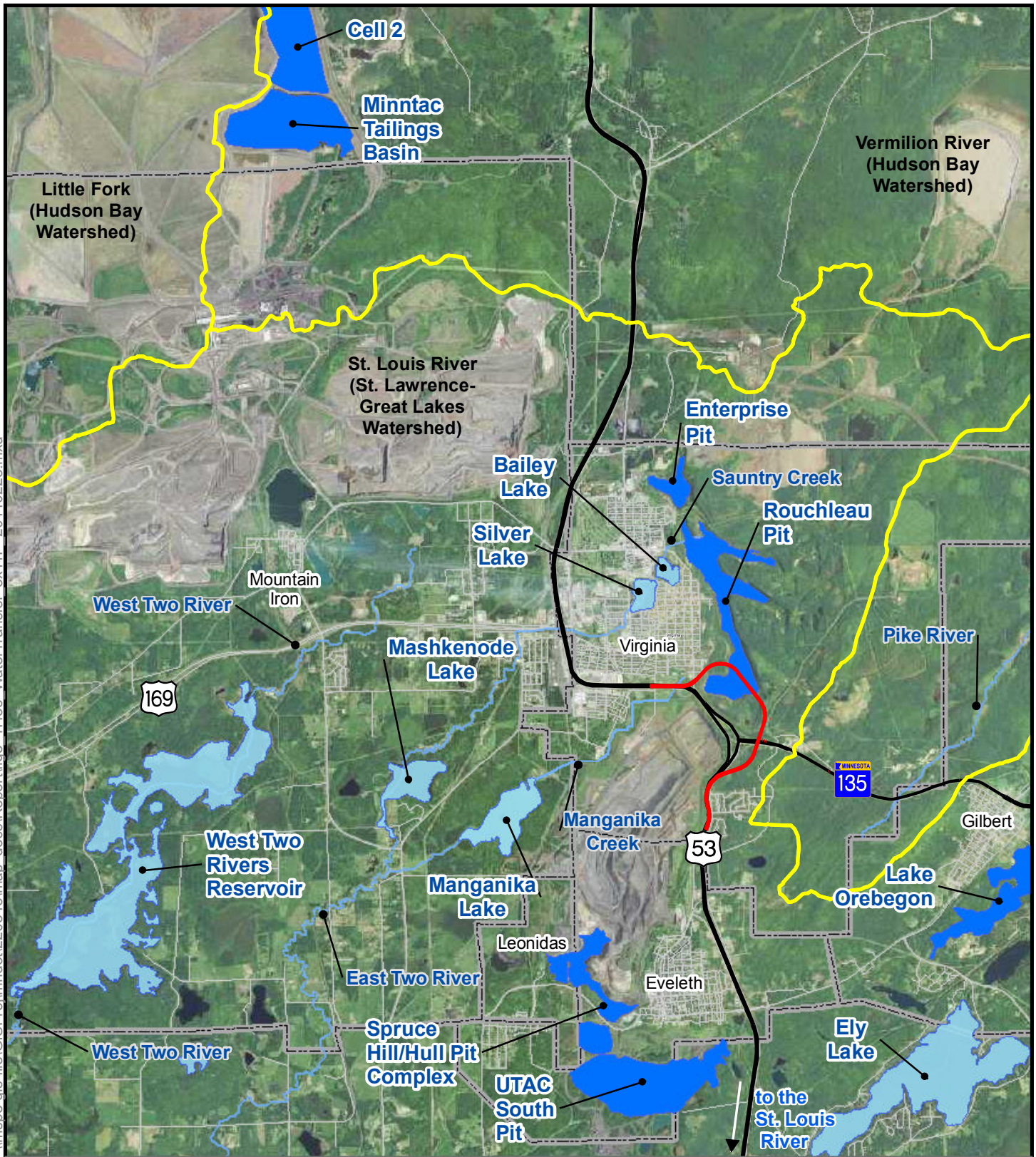
Figure 2: Rouchleau Pit Area, Water Supply Facilities
Th 53 Alternative E-1A - RSS Option
Water Management Study



0 0.25 0.5
Miles

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- Major watershed
- E-1A Alignment
- Lake Pit
- Lake
- Stream or ditch

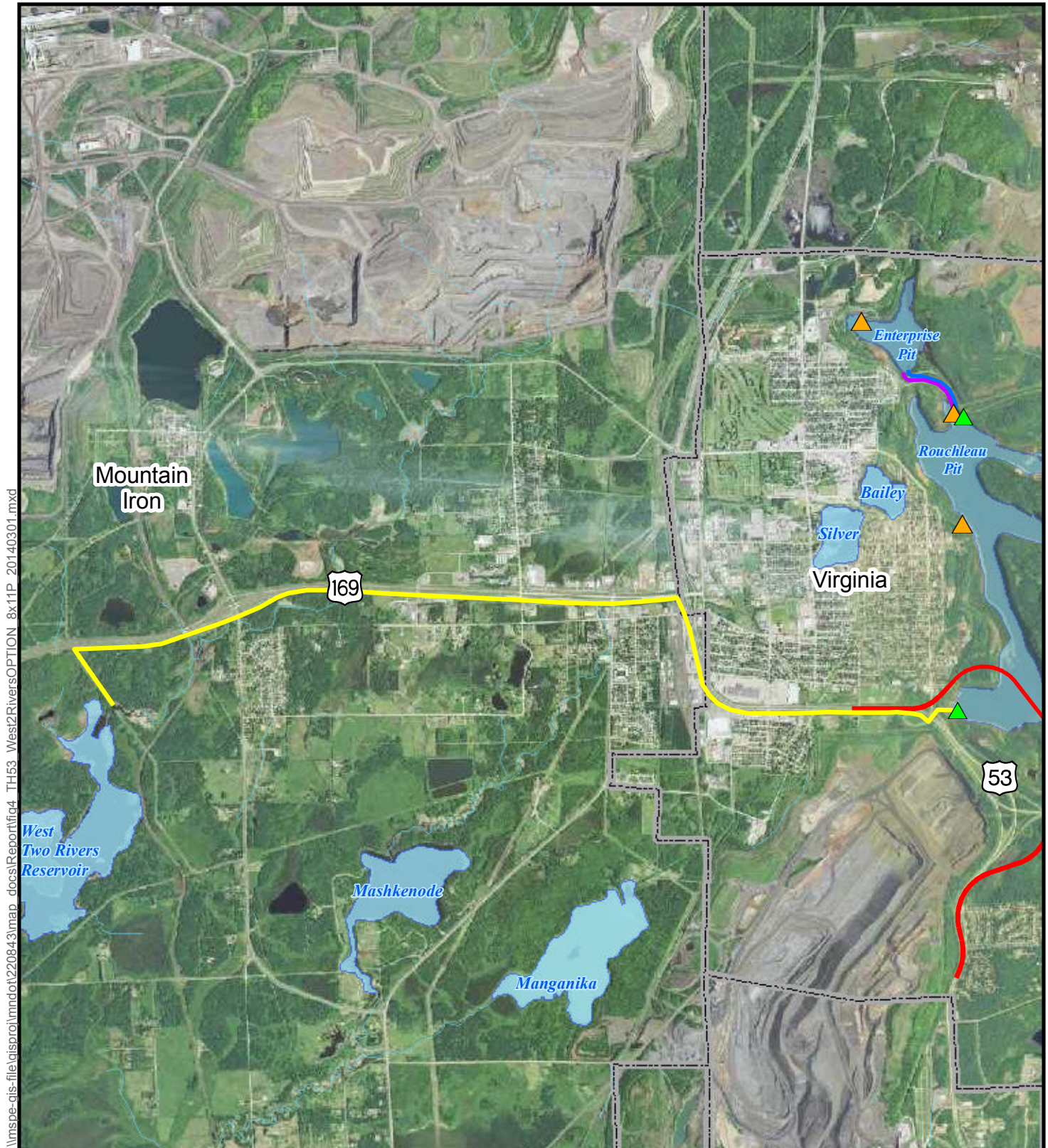
Figure 3: Water Transfer Analysis

TH 53: Alternative E-1A - RSS Option
Water Management Study



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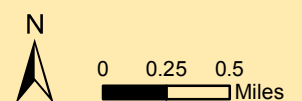
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|---|--|
|  E-1A Alignment | Pumping station |
| Dewatering pipe |  Existing |
|  West Two Rivers Reservoir route |  Proposed |
|  Enterprise Pit route | |
|  Existing Arcelor Mittal Pipe | |

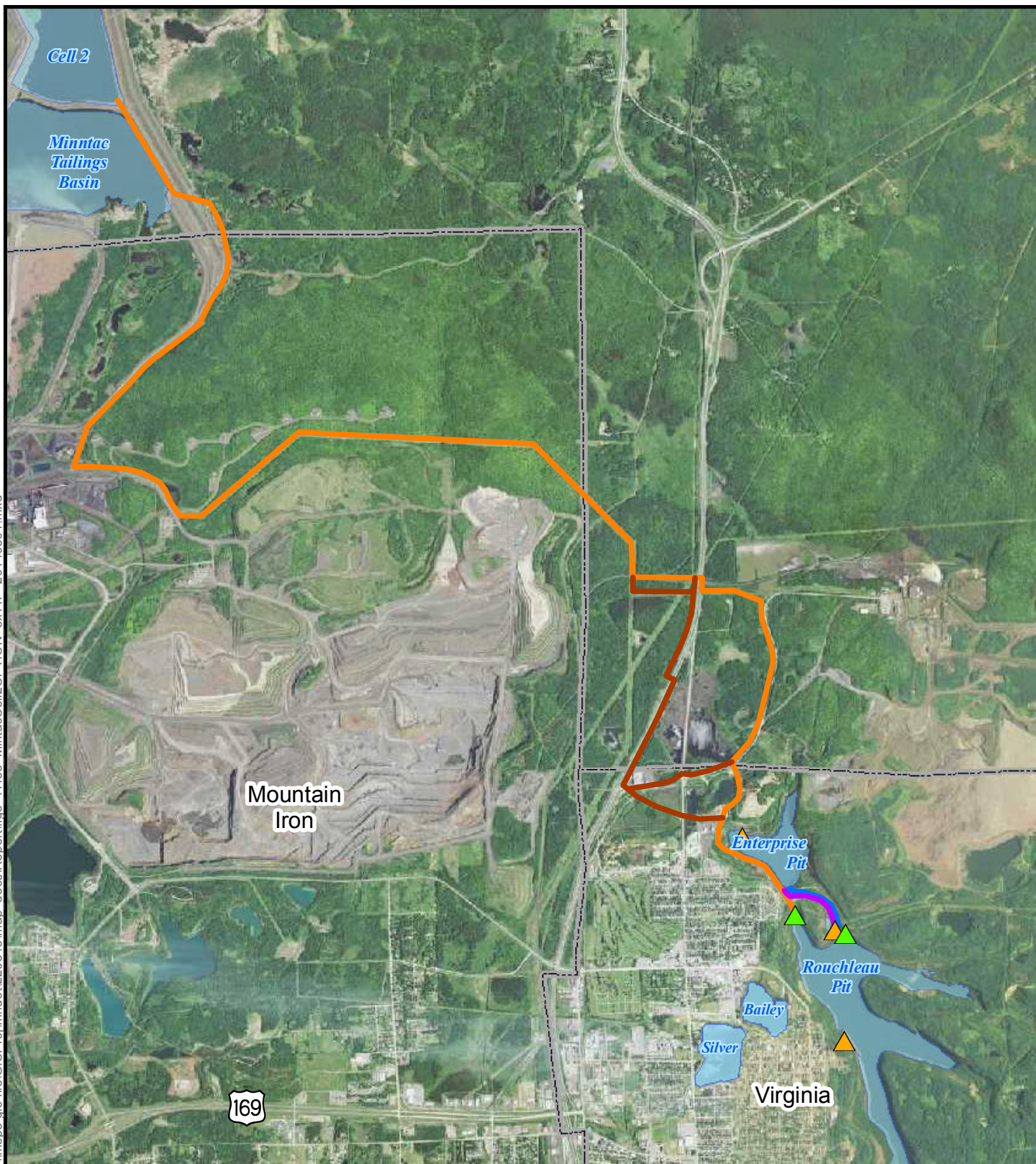
Figure 4: West Two Rivers Reservoir Option
TH 53: Alternative E-1A - RSS Option Water Management Study



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Dewatering pipe

- Orange line: Minntac Tailings Basin Cell 2 route
- Brown line: Minntac Cell 2 Alternative routes
- Blue line: Enterprise Pit route
- Purple line: Existing Arcelor Mittal Pipe

Pumping station

- Orange triangle: Existing
- Green triangle: Proposed

Figure 5: Minntac Cell 2 Option

TH 53: Alternative E-1A - RSS Option
Water Management Study



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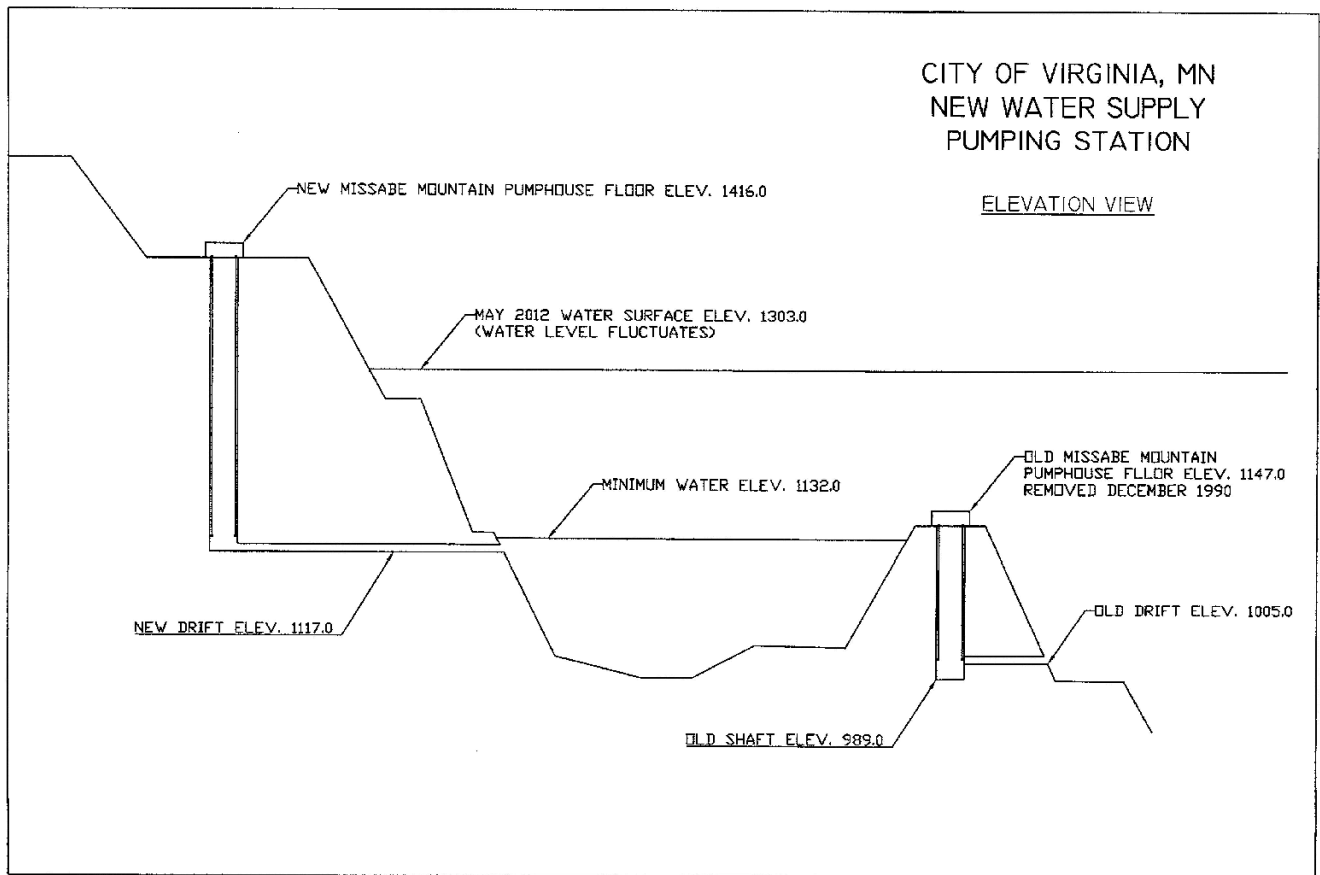
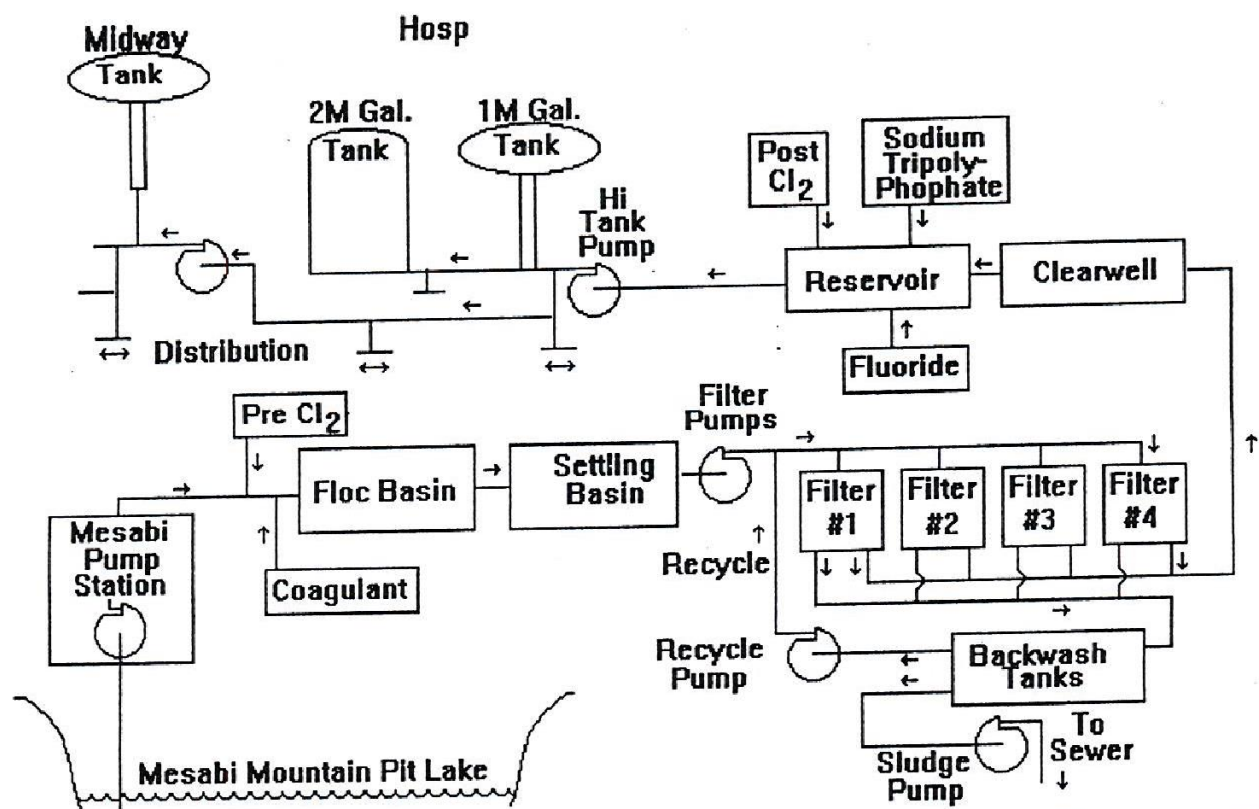
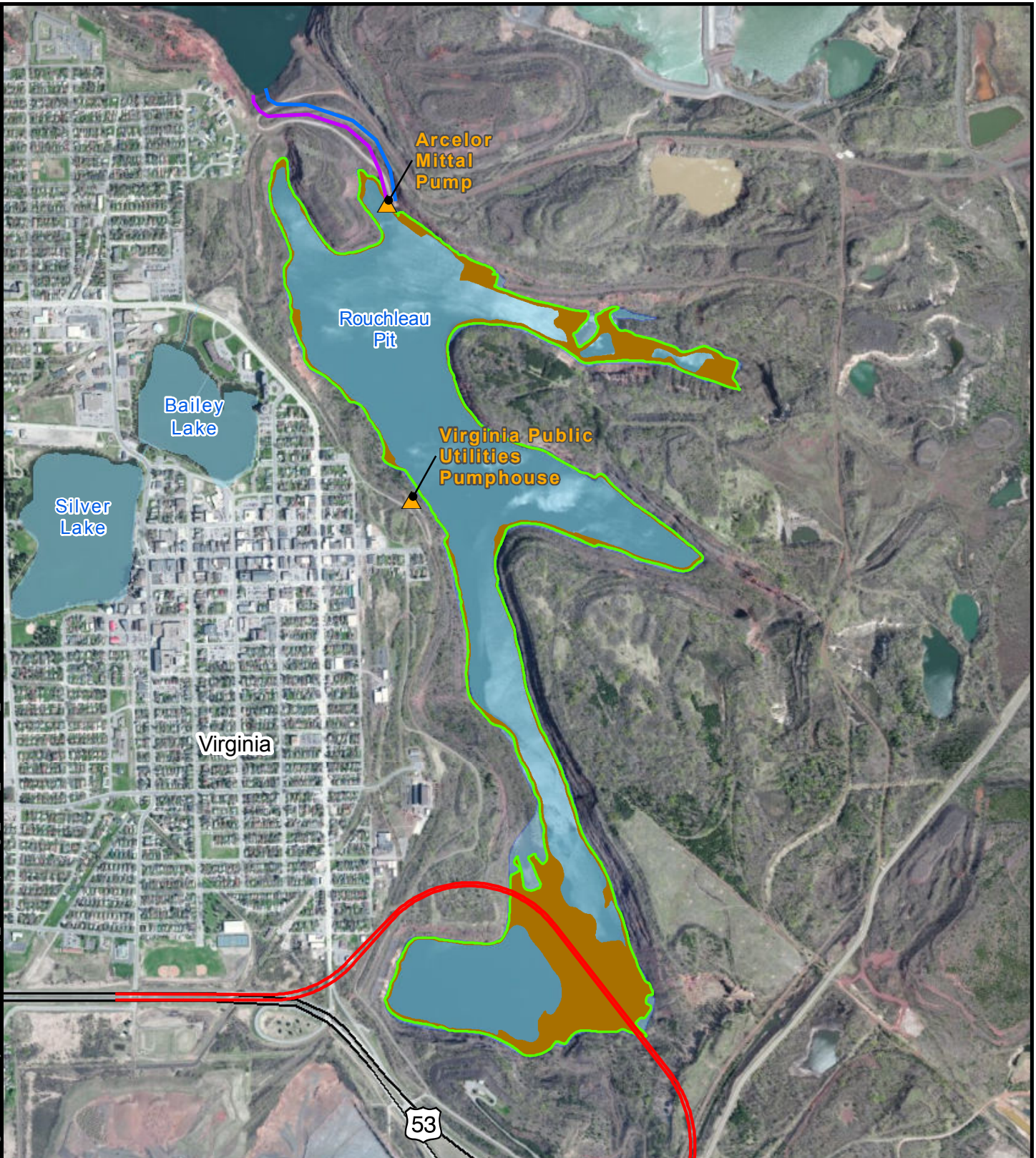


Figure 6: Virginia Public Utilities Existing Intake
TH 53: Alternative E-1A - RSS Option
Water Management Study



Virginia Department of Public Utilities Water Treatment Plant

Figure 7: Water Treatment Plant
TH 53: Alternative E-1A - RSS Option
Water Management Study



- 2013 water surface elevation: 1,305 feet
- Exposed land at 1,275 feet
- Pumping station
- Enterprise Pit route
- Arcelor Mittal Pipeline
- E-1A Alignment

Figure 8: Water Surface Elevations

TH 53: Alternative E-1A - RSS Option
Water Management Study



0 0.25 0.5
Miles

**TECHNICAL APPENDIX
HYDROGEOLOGIC INVESTIGATION**

**TH 53 RELOCATION ALTERNATIVE E-1A
REINFORCED SOIL SLOPE (RSS) CONSTRUCTION OPTION
WATER MANAGEMENT STUDY
HYDROGEOLOGIC INVESTIGATION
SEPTEMBER 2014**

1.0 INTRODUCTION

As part of the evaluation of the Alternative E-1A Reinforced Soil Slope Option (RSS Option) for the realignment of Trunk Highway 53 (TH53), HDR Engineering, Inc. conducted an analysis of the effect of partially dewatering the Rouchleau Pit¹ (Pit) to accommodate dry construction of the proposed highway embankment. This Technical Appendix provides information on the hydrogeologic conditions in the area and an estimate of the groundwater inflow during pit dewatering using a simple groundwater flow model. A location map is shown on Figure 1. The Rouchleau Pit vicinity is shown on Figure 2.

2.0 GEOLOGIC AND HYDROGEOLOGIC SETTING

2.1 GEOLOGY

The Rouchleau Pit is located just east of the City of Virginia in the Mesabi Iron Range (Cotter and others, 1965a), as shown on the bedrock geology map provided on Figure 3. The Mesabi Range is an iron-rich area where the Biwabik Formation outcrops. It is a strip approximately 120 miles long stretching from Grand Rapids in the southwest to Babbitt in the northeast (Morey, 1992; Cotter and others, 1965a). Where exposed at the surface, its outcrop is ¼ to 3 miles in width (Morey, 1992; Meineke and others, 1993).

The Giants Range Granite Formation outcrops approximately 1.5 miles north of the Rouchleau Pit and forms a topographic high that cause a drainage divide (the Laurentian divide). Water to the north of the Laurentian divide drains north eventually reaching Hudson Bay. Water south of the divide flows to the St. Louis River and Lake Superior.

South of the Giants Range under a mantle of glacial drift is a sequence of bedrock units including the Virginia Argillite, the Biwabik Formation, the Pokegama Quartzite, and Archean-aged basement rocks including the Ely Greenstone. These units have been warped into a Z-shaped geologic feature known as the “Virginia horn” in the vicinity of the Rouchleau Pit, causing the contacts of the Biwabik Formation with the Pokegama Quartzite and Virginia Argillite to assume the same shape. At Virginia, these formations have been folded, trending north to south, rather than following the normal east-west trend of the Mesabi Range.

2.2 HYDROGEOLOGIC UNITS

¹ The water body is referred to as the Missabe Mountain Pit, the Missabe Mountain Pit Lake and the Rouchleau Pit in different sources. It will be referred to as the Rouchleau Pit throughout this report.

A generalized description of the major hydrogeologic units is provided in Table 1. A map showing the thickness of the units at selected well locations is provided on Figure 4. A detailed description of the major hydrogeologic units follows:

Glacial Drift

A layer of glacial drift covers most of the region and is only absent in mine pits and where bedrock outcrops. The thickness of the glacial drift varies widely, from zero feet where the Giants Range Granite outcrops, to 120 feet thick within 0.5-mile of the Rouchleau Pit. Exploration boring logs indicate the drift is about 15 to 40 feet thick near the Rouchleau Pit. The glacial drift is described as red clayey till in the regional hydrogeologic studies by Winter (1973), Lindholm and others (1979) and Cotter and others (1965b), and generally acts as a low-permeability unit (aquitard) and can only supply water for domestic purposes. The hydraulic conductivity of the glacial drift is expected to be low. However, the drift can contain sand and gravel glaciofluvial deposits, such as on the west side of Virginia, where a well screened from 69 to 94 feet deep produced 1,400 gpm (HDR, 1997).

Virginia Argillite

The Virginia Argillite is described as thinly bedded gray to black argillite, siltstone, and shale with a maximum thickness of 2,000 feet (Cotter and others, 1965a). It generally acts as an aquitard and forms an upper confining unit to the underlying Biwabik Formation, but can supply enough water for domestic purposes. Where the Virginia Argillite has been eroded the Biwabik Formation is exposed (see Figure 3) and targeted for iron ore mining. The Virginia Formation is absent at the Rouchleau Pit and to the north and east of the pit. The Virginia Formation appears under the City of Virginia and thickens to the south and west, and is 720 feet thick at exploration borehole VHD-00-1 four miles southwest of the pit (see Figure 4). The Virginia Argillite extends many miles south of the Mesabi Range.

Biwabik Formation

The Biwabik Formation is the primary formation of interest since it is exposed in the Rouchleau Pit and directly controls the amount of groundwater flowing into the pit. The Biwabik Formation is comprised of layers of cherty and slaty members, with cherty members containing iron oxides and slaty members containing iron silicates and iron carbonates, and has been intensely folded near the pit. The Biwabik Formation is unconfined at mine pits and where the unit subcrops under thin glacial deposits, and is confined where overlain by the Virginia Argillite southwest of the Rouchleau Pit. Approximately 1.5 miles north and east of the pit the Biwabik Formation pinches out completely and is bound by the Giants Range Granite and other Archean-aged rocks of low-permeability. The Biwabik Formation is inferred to extend ten miles south of the City of Virginia based on magnetic and gravity geophysical surveying (Jirsa, 2013). Well logs indicate the Biwabik Formation is 435 to 600 feet thick near the Rouchleau Pit and thickens to the southwest where it is 740 feet thick at exploration borehole VHD-00-1 (see Figure 4). The top of the formation slopes approximately 3% downward to the southwest from the pit to borehole VHD-00-1. The hydraulic conductivity of the Biwabik Formation is generally low and has been reported to range from 0.0046 to 5 ft/day (HDR, 1997). The above estimates

of hydraulic conductivity generally agree with a state-wide aquifer study by Kanivetsky and Walton (1979), who estimated a hydraulic conductivity of 0.33 to 6.6 ft/day. Kanivetsky and Walton (1979) also give an aquifer storativity of about 10^{-5} to 10^{-3} for the Biwabik Formation. In places where the formation is locally fractured it can yield up to 1,000 gpm to wells.

Pokegama Quartzite

The Pokegama Quartzite underlies the Biwabik Formation and is described as a varicolored vitreous quartzite, siltstone, and shale by Cotter and other (1965a) and Jirsa and others (2005). It generally acts as a low-permeability aquitard but can supply enough water for domestic purposes. The Pokegama Quartzite is the lower terminus for mining activities and most exploration boreholes. It only outcrops or subcrops in a very narrow margin north of the Biwabik Formation (see Figure 3), and is otherwise buried deeply under the overlying bedrock formations. The Pokegama Quartzite is up to 350 feet thick (HDR, 1997), and likely extends many miles south of the Mesabi Range.

Table 1
Description of Major Hydrogeologic Units

Formation or Group	Maximum Thickness (feet)	General Lithology	Water-bearing Characteristics
Glacial Drift	120	Varies from clay till to outwash sand and gravel.	Typically utilized for domestic supplies. Can yield up to 1,400 gpm in glaciofluvial deposits.
Virginia Argillite	2,000	Thinly bedded gray to black argillite.	Yields up to 30 gpm from fractured zones near its upper surface. Utilized for numerous domestic supplies and for Iron Junction municipal supply.
Biwabik Formation	800	Taconite – dark-colored hard dense iron-bearing silicic rock. Ore – black, yellow, or red, soft iron-bearing porous rock.	Yields up to 1,000 gpm to wells in highly fractured taconite and ore. Utilized for numerous municipal and industrial supplies.
Pokegama Quartzite	350	Varicolored vitreous quartzite.	May yield 5-15 gpm from fractured zones near its upper surface.
Giants Range Granite	Unknown	Hornblende granite and biotite granite.	Yields 5-15 gpm from fractured zones near its upper surface.
Ely Greenstone	Thousands	Schist, altered basaltic lavas, and clastics.	May yield 5-15 gpm from fractured zones near its upper surface.

Source: Modified from Cotter and others (1965a).

3.0 GROUNDWATER ELEVATIONS, FLOW DIRECTIONS AND RECHARGE/DISCHARGE

Throughout most of the region, the upper-most saturated zone and groundwater table is located in the drift material. Under natural conditions the groundwater table is a subdued image of the land surface. Throughout the Mesabi Range, the groundwater table is likely within 25 feet below ground surface (Winter, 1973; Cotter and others, 1965a). Lindholm and others (1979, Plate 1) provide a large scale groundwater contour map for the St. Louis River watershed for the upper-most water bearing zone developed from relatively shallow wells. This map indicates groundwater flow is generally to the south or southwest (away from the Giants Range) in the Virginia area. The water table elevation at Virginia is approximately 1,400 to 1,450 ft MSL².

Within the project area surrounding the Rouchleau Pit the Biwabik Formation is the upper water bearing formation. Groundwater flow in the Biwabik Formation is expected to flow from the north to the southwest (HDR, 1997) following the regional groundwater gradient reported by Lindholm (1979) and to be partially influenced by mine dewatering. In pits that are not subject to pumping the pit water level may represent the potentiometric surface for the Biwabik Formation. Figure 5 shows groundwater levels in wells and mine pits (both active and inactive) completed within the Biwabik Formation from 1981 to 2012 (time-synoptic groundwater level and mine pit water level data was not available). The groundwater levels range from 1,216 to 1,467 feet. The effects of mine dewatering on groundwater levels appear to be localized to areas near the pits and appear not to have caused a wide-spread drawdown of groundwater levels in the formation. For example, the 1997 HDR report shows November 20, 1996 water levels in the Rouchleau Pit (1,216 ft) to be 180 feet lower than the water level in the City of Virginia well (1,396 ft) installed 3,000 feet from the pit.

The average annual precipitation for the area is approximately 27 inches and the average annual surface water evaporation is 23.5 inches (USDA, 1975). The groundwater recharge rate near Virginia is 12-25 percent of annual precipitation (Dellin et al., 2007), which equates to a groundwater recharge rate of 3 to 7 inches/year.

4.0 MINE PIT LAKES AND GROUNDWATER PUMPING

The Rouchleau Pit was created from the mining of the Biwabik Formation for iron ore starting in the late 1800s. The current Rouchleau Pit was formerly several separate mining pits that have since filled with water and become one water body. From north to south, these former pits consisted of: the Columbia Pit, the Missabe Mountain Pit, the Shaw-Moose Pit, the Rouchleau Pit, and the southern Rouchleau Extension, all of which were mined for iron ore from the late 1800s into the 1980s. When mining activity and dewatering ceased in the 1980's the water level in the pits rose, eventually forming one water body.

A bathymetric survey completed in July 2013 (MnDOT, 2013) indicates the deepest pit elevation is 985 ft, which would constitute the maximum extent of dewatering during mining. The most-recent historic high water elevation in the pit is 1,310 ft measured in December 2009 (NTS, 2013). During September 2013, the water elevation in the pit was 1,305 ft.

² All elevations are referenced to mean sea level.

The pit water level is currently influenced by pumping by the City of Virginia, which uses the water for municipal water supply, and by ArcelorMittal, which pumps from the Rouchleau Pit to the nearby Enterprise Pit. In 2011 the City of Virginia pumped an average of 1,794 gpm from the Rouchleau Pit. ArcelorMittal pumped an average of 1,215 gpm from the Rouchleau Pit in 2012. The Enterprise Pit is approximately 1,000 feet to the north and supplies water to ArcelorMittal for operations at the Minorca Mine. On September 30, 2013, the water elevation in the Enterprise Pit was 1,312 feet.

Other mine pits exist around the Rouchleau Pit that are, or have been, dewatered by pumping. Active mine pits include the Cliffs-UTAC Thunderbird Pit approximately one mile to the southwest, which is dewatered at 2,000-2,700 gpm. U.S. Steel-Minntac currently dewateres at mine pits approximately two miles to the northwest. ArcelorMittal operates the Minorca Mine approximately 0.5-mile to the northeast but does not dewater and currently disposes tailings into the Minorca Pit. The water elevation in the Minorca Pit on October 29, 2012 was 1,468 feet, up from 1,401 feet in November 1998 (NTS, 2013).

The water level in the Rouchleau Pit has historically been influenced by some sort of pumping, either by mines or the City of Virginia. If all pumping were to cease in the pit, it is conceivable that the water level may rise to an elevation similar to that in the City of Virginia well, which was 1,396 ft MSL in November 1996 and 1,428 ft MSL in June 1982 (HDR, 1997). The ultimate water level in the pit would be influenced by dewatering activities in the Biwabik Formation by other mines in the area.

Groundwater inflow into the Rouchleau Pit has been calculated in water balance studies by others. HDR (1997) indicates a groundwater inflow of 2,135 gpm into the pit during the 1991-1995 timeframe, factoring pumping by the City of Virginia into the water balance. NTS (2013) calculated a groundwater inflow of 2,306 gpm into the pit during the 2004-2012 timeframe; this includes pumping by the City of Virginia over the entire timeframe and ArcelorMittal pumping starting in 2008.

5.0 GROUNDWATER USE

Numerous domestic and non-domestic water supply wells are installed in the glacial drift and Virginia Argillite. Comparatively few wells are installed in the Biwabik Formation in the vicinity of the Rouchleau Pit. Table 2 contains a list of wells in the Biwabik Formation within approximately one mile of the pit and that are used for water supply. These wells are also shown on Figure 6.

The City of Virginia has a well located near the steam plant on the south side of Silver Lake that is open to the Biwabik Formation from 118 to 450 feet, but the well is not in use. The City of Mountain Iron has two wells open to the Biwabik Formation from 1,180 to 1,295 ft (Well 1) and 1,030 to 1,295 ft (Well 2), pumping approximately 114 gpm each annually (Walsh, 2009). These wells are about four miles west of the Rouchleau Pit. The open areas in these wells are well below the 30-foot dewatering depth proposed for the TH 53 Alternative E-1A – RSS Option.

Table 2
Biwabik Formation Water Supply Wells

Township-Range-Section	Unique Well ID	Name	Use	Ground Surface Elevation (ft MSL)	Depth (ft)
58-17-08	476180	Virginia 1	Municipal	--	288
58-17-08	476181	Virginia 2	Municipal	--	287
58-17-10	534407	St. Louis Co. Health Dept.	Public Supply	1,695	308
58-17-10	626721	St. Louis Co. Solid Waste	Industrial	1,696	366
58-17-16	239254	Johnson, Raymond	Domestic	1,633	173
58-17-22	668979	A Plus Auto Salvage	Commercial	1,588	325

(Source: Minnesota County Well Index)

6.0 GROUNDWATER MODELING EVALUATION OF PIT DEWATERING

A simple groundwater model was developed to evaluate the effect of partially dewatering the Rouchleau Pit on groundwater flow rates into the pit, and groundwater levels in the vicinity. The following sections present the details and results of the evaluation.

6.1 MODEL CONSTRUCTION AND PROPERTIES

This section describes the parameters used to construct the model.

6.1.1 MODEL CODE AND SOLVER

The groundwater model was developed using the USGS program, MODFLOW 2000 (Harbaugh et al., 2000) using the PCG2 solver with inner and outer closure criterion set to 1 and 0.01 feet. The pre-processor used for the analysis was Groundwater Vistas.

6.1.2 MODEL DOMAIN AND GRID

The model domain consists of an approximately 7.6 mile by 5.7 mile (43 square mile) rectangular area in the vicinity of the Rouchleau Pit. The model domain was discretized into a grid with 80 rows and 60 columns, and uniform 500 foot by 500 foot cells in plan view (Figure 7). The grid was rotated clockwise as shown on Figure 7 to follow the northeast-southwest orientation of the outcrops on the Biwabik Formation and the regional groundwater flow direction. The grid was designed to include the Rouchleau Pit in the northeast corner, and to extend from the pit to the southwest in the general direction of dip of the Biwabik Formation, which is the geologic unit that contacts the pit. Grid cells were set as inactive in the northern and northeastern areas of the model domain where the Biwabik Formation is not present.

6.1.3 MODEL LAYERS

The model consists of one layer representing the Biwabik Formation. Although other geologic units are present within the model domain (the overlying glacial drift and Virginia Argilite and the underlying Pokegama Quartzite) they are not significant water bearing units and are not anticipated to contribute groundwater flowing into the pit. The top of layer 1 is shown on Figure 8. The top of layer 1 was set at the ground surface elevation in the area where the Biwabik Formation outcrops or is the uppermost bedrock formation. A 3 percent slope in the downdip direction was assigned to the top of model layer 1 in the southwest where the Virginia Argilite overlies the Biwabik Formation. The layer thickness was set at a uniform thickness of 750 ft, based on available well log information. This is a conservative approach to specifying aquifer thickness for the purpose of estimating groundwater inflow into the pit, because the formation is slightly thinner (500-600 feet) in the northern areas.

6.1.4 MODEL BOUNDARIES AND AQUIFER PROPERTIES

North and South Constant Head Boundaries

The model includes two constant head boundaries in the north and south and shown in Figure 9. The groundwater potentiometric elevation information available for the Biwabik Formation is data collected over several decades and is influenced by changing mine pit dewatering practices. Therefore, the groundwater elevations set at the boundaries were estimated from that data and set to maintain a southwest flow direction with groundwater levels near the mine pit ranging from 1,380 to 1,400 feet. The elevation data used for the boundaries is based on a review of all the available information and represents best professional judgment

A linear constant head boundary was placed in the northern part of the model grid initially set at elevations ranging from 1,400 to 1,450 and calibrated to an elevation of 1,400 feet. At the southern edge of the model a constant head boundary was set initially at an elevation of 1,350 to 1,400 feet and calibrated to an elevation of 1,350 feet.

Rouchleau Pit Drain Boundary

The Rouchleau Pit is modeled as a drain to simulate groundwater inflow from current pumping and future dewatering. The drain was set at the current static water level elevation in the pit (1,305 feet) maintained by pumping.

Aquifer Recharge

Two recharge zones are defined in the model. Recharge was set at 4 inches/year in the north and northeastern areas of the model domain in areas where the Biwabik Formation outcrops or is the shallowest bedrock unit and is likely to receive the most significant recharge. Recharge was set at 1 inches/year for areas where the glacial drift and the Virginia Argilite overlies and confines the Biwabik Formation and the recharge is likely to be much lower.

Aquifer Properties (K and S)

The initial hydraulic conductivity (K) values assigned ranged from 1 to 6 feet/day and the calibrated hydraulic conductivity was 6 feet/day. A storage coefficient (S) of 1×10^{-5} was assigned to the single model layer based on the aquifer-specific hydraulic properties summarized in previous sections of this report.

6.2 STEADY-STATE CALIBRATION

The model was first run for time-static conditions using the boundary and aquifer property inputs described above. The steady-state model was calibrated by adjusting aquifer recharge, the north and south constant head boundaries and aquifer properties and comparing the simulated output at the Rouchleau Pit drain. The final model calibration resulted in an aquifer hydraulic conductivity of 6 feet/day, an aquifer recharge of 4 inches/year in the north and 1 inches/year in the south and a constant head boundary in the north at elevation 1,400 feet and in the south at elevation 1,350 feet.

Simulated steady state groundwater elevations are shown in Figure 10. The simulated steady-state calibrated inflow rate required to maintain the Rouchleau Pit elevation at 1,305 ft was 5,993 gallons per minute (gpm). This is significantly higher than the estimated groundwater inflow to the pit from water balance calculations of 2,100 to 2,300 gpm as described above. The reason is that the model does not include dewatering from other nearby mine pits (described previously), and those dewatering activities contribute to lowered groundwater levels in the region and in the Rouchleau Pit. Not including those dewatering rates from other nearby mines in the model causes an over-prediction of the groundwater level and inflow to the Rouchleau Pit. It was beyond the scope of this model to include those other mine pit dewatering systems in the model domain. By not including the other nearby pit dewatering, the model is conservatively over-estimating the estimated inflow to the pit at both the current and future water elevation.

7.0 ESTIMATED GROUNDWATER INFLOW TO PIT DURING DEWATERING

The groundwater inflow to the pit during dewatering to elevation 1,275 feet was estimated using a transient simulation setting the pit drain boundary elevation to 1,275 feet. Simulated hydraulic head data from the calibrated steady-state simulation were used as starting head inputs for the transient simulation for the following stress periods: 1 month, 2 months, 6 months, 1 year, 5 years, 10 years, 50 years, and 100 years. The computed steady-state drain inflow rate was subtracted from the computed transient drain inflow rate to calculate the additional estimated drain inflow. The additional drain inflow is estimated to be up to 3,400 gpm during the first month and then decrease to approximately 2,060 gpm during subsequent years, as shown on Table 3. This assumes that the water level is quickly reduced to elevation 1,275 feet. In reality, it will take approximately three months for the dewatering system to reduce the water level in the pit to 1,275 feet and the additional inflow will actually be less than 3,400 gpm. However, for the purposes of engineering design it can be assumed that the dewatering system will need to accommodate up to 3,400 gpm of groundwater inflow (in addition requirements for initial drawdown of the water volume). Simulated groundwater levels are shown on Figure 11 and indicate that the effects of dewatering will be limited to the immediate area around the pit and localized groundwater elevations will decrease approximately 10 to 20 feet in the vicinity of the City of Virginia.

Table 3
Simulated Groundwater Inflow to Pit
During Dewatering Above Current Inflow Rates

Elapsed Time From Start of Dewatering	Additional Groundwater Inflow Resulting From Dewatering From 1,305 to 1,275 Ft MSL (gpm)
1 month	3,407
2 months	2,623
6 months	2,117
12 months	2,062
5 years	2,059
10 years	2,059
50 years	2,059
100 years	2,059

Note: Table shows additional groundwater inflow simulated to occur from lowering pit water level from 1,305 to 1,275 feet elevation. This is in addition to the pumping already occurring.

8.0 SUMMARY

The Alternative E-1A – RSS Option for the relocation of TH-53 would require decreasing the water level in the pit from elevation 1,305 feet (as measured in 2013) to elevation 1,275 feet to allow dry construction of the embankment by the reinforced soil slope construction method. This will cause an increase in groundwater inflow to the pit and a depression of regional groundwater levels. An evaluation was conducted to determine the rate of groundwater flow into the pit and to estimate the decrease in groundwater levels in the vicinity caused by the temporary dewatering operations.

The Biwabik Formation is the primary aquifer contributing flow into the Rouchleau Pit. The Biwabik Formation is unconfined at the mine pits and groundwater levels in the area are higher than the water levels in the pits. Pits that are actively mined are pumped (dewatered) to control groundwater inflow. Well logs indicate the Biwabik Formation is 435 to 600 feet thick near the Rouchleau Pit and thickens to the southwest where it is 740 feet thick at exploration borehole VHD-00-1 (see Figure 4). The hydraulic conductivity of the Biwabik Formation is generally low and has been reported to range from 0.0046 to 5 ft/day (HDR, 1997) and from 0.33 to 6.6 ft/day (Kanivetsky and Walton, 1979). Kanivetsky and Walton (1979) also give an aquifer storativity of about 10^{-5} to 10^{-3} for the Biwabik Formation. Well yields are typically low except in places where the formation is locally fractured it can yield up to 1,000 gpm to wells.

The effects of mine dewatering on groundwater levels appear to be localized to areas near the pits and appear not to have caused a wide-spread drawdown of groundwater levels in the formation. For example, the a map in the report by HDR (1997) showing November 20, 1996 water levels indicates the water level in the Rouchleau Pit (1216 ft MSL) was 180 feet lower than the water level in the City of Virginia well (1396 ft MSL) installed only 3,000 feet from the pit.

Domestic and non-domestic water supply wells are installed in the glacial drift and Virginia Argillite. Comparatively few wells are installed in the Biwabik Formation in the vicinity of the Rouchleau Pit.

A simple groundwater model was developed to evaluate the amount of increased groundwater flowing into to the Rouchleau Pit by lowering the water level from elevation 1,305 feet to 1,275 feet to allow dry-construction of the embankment for the TH-53 highway relocation Alternative E-1A – RSS Option. The additional drain inflow is estimated to be up to 3,400 gpm during the first month and then decrease to approximately 2,060 gpm, as shown on Table 3. Simulated groundwater levels are shown on Figure 11 and indicate that the effects of dewatering will be limited to the immediate area around the pit and local groundwater elevations will decrease approximately 10 to 20 feet in the vicinity of the City of Virginia. The 10 to 20 foot decline in the groundwater levels in the vicinity of the Rouchleau Pit is not expected to affect water levels in the intake zones of existing wells. The temporary dewatering is not expected to affect well operations.

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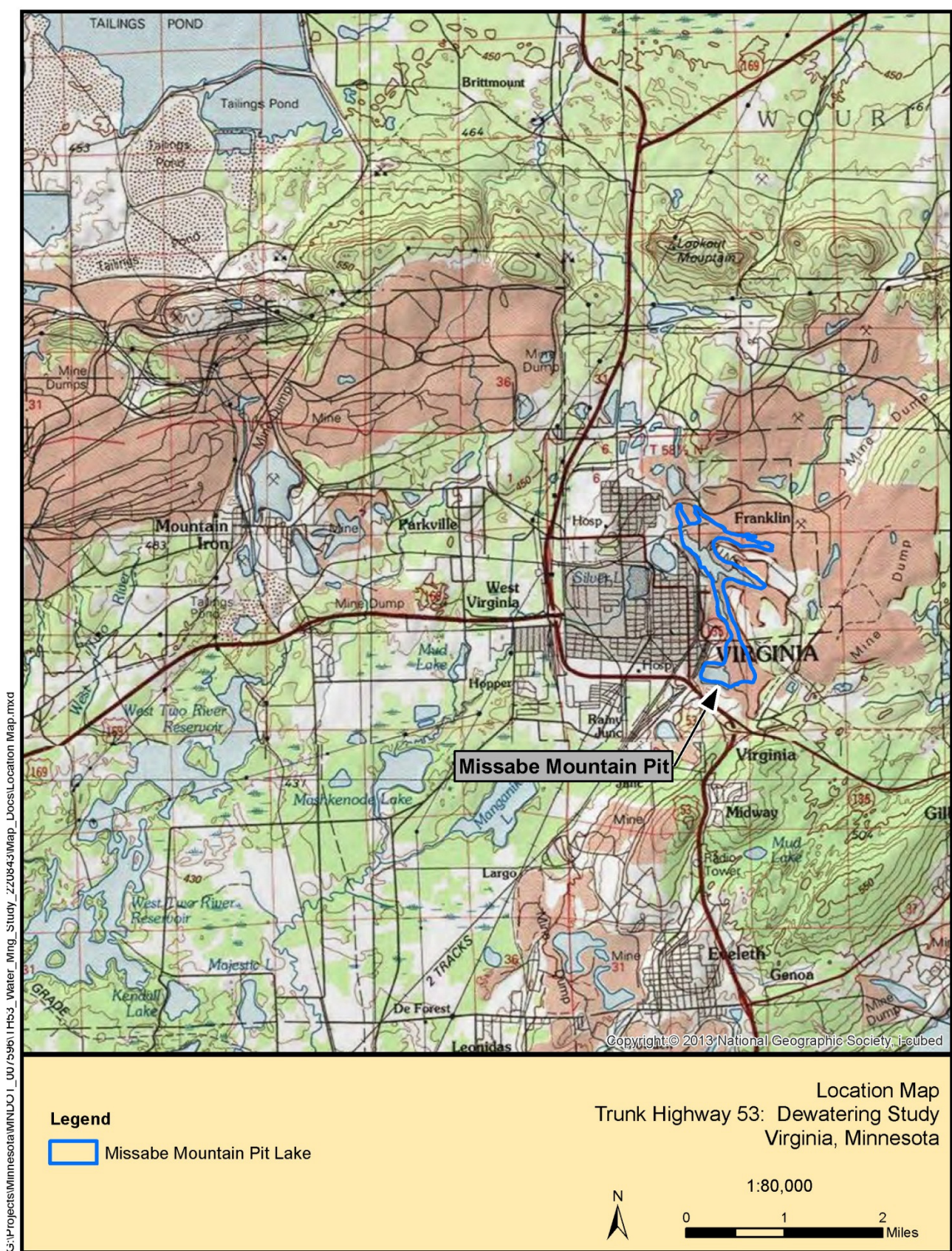
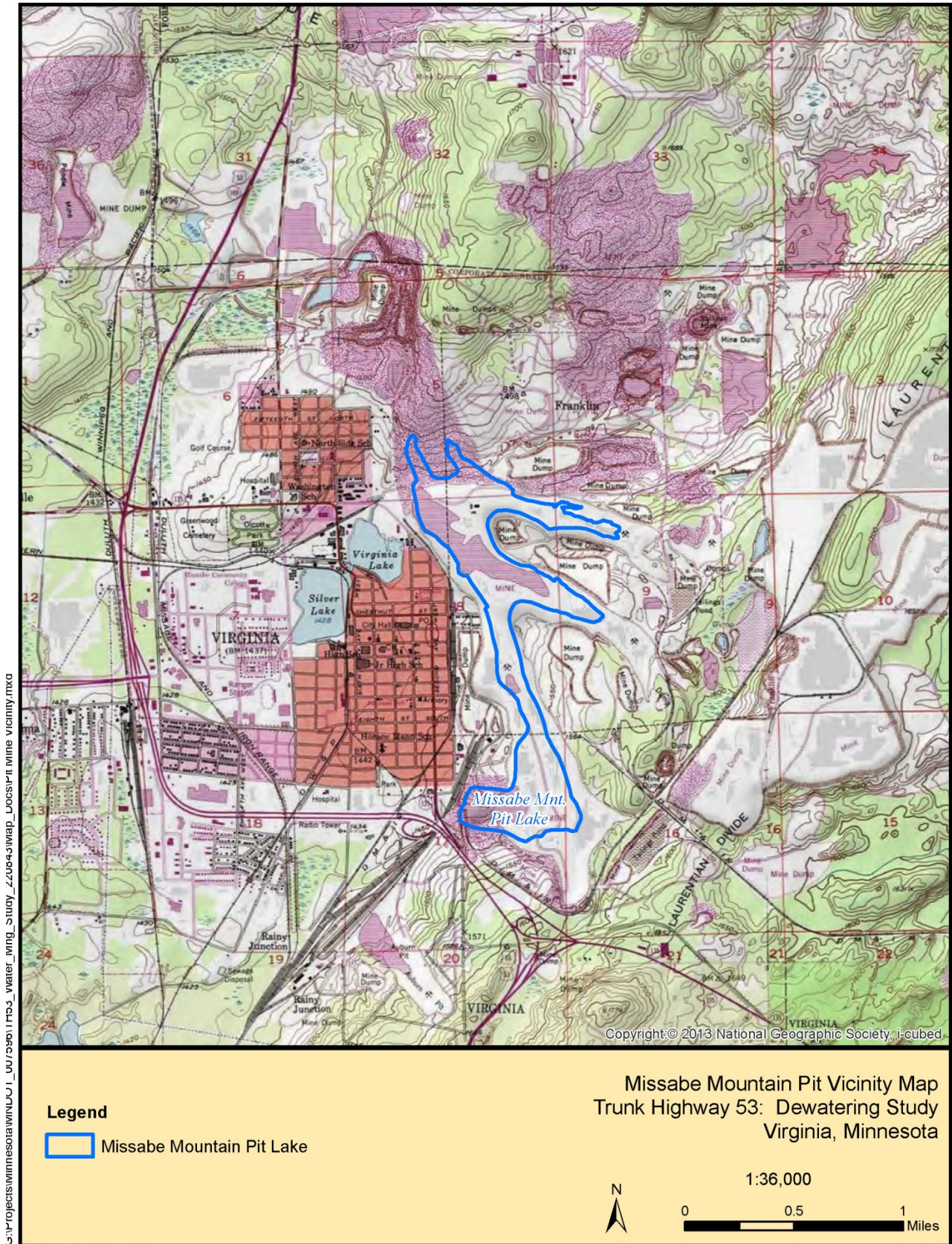


Figure 1 Location Map



Date: 11/15/2013

Figure 2 Rouchleau Pit Vicinity Map

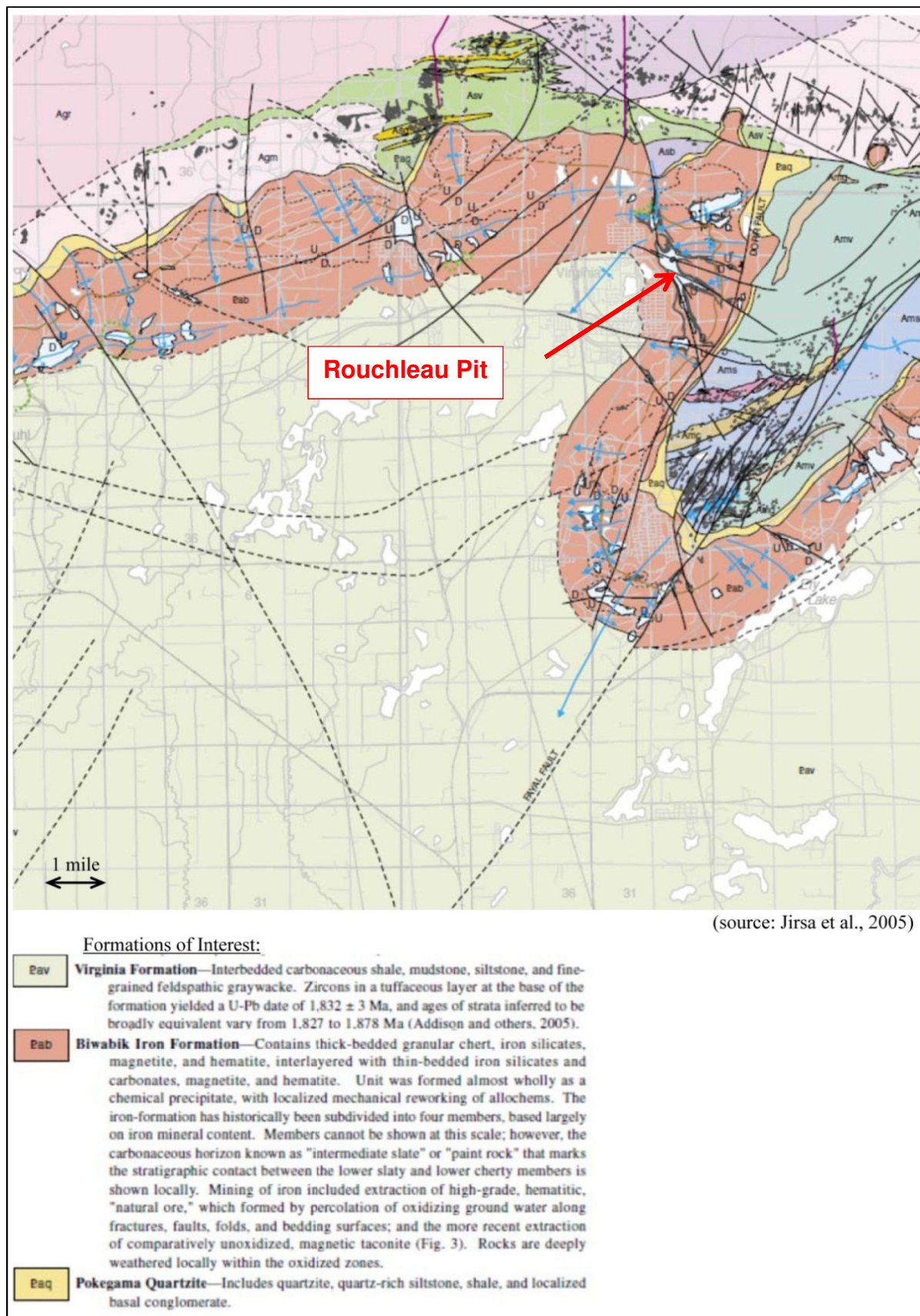


Figure 3 Bedrock Geology Map

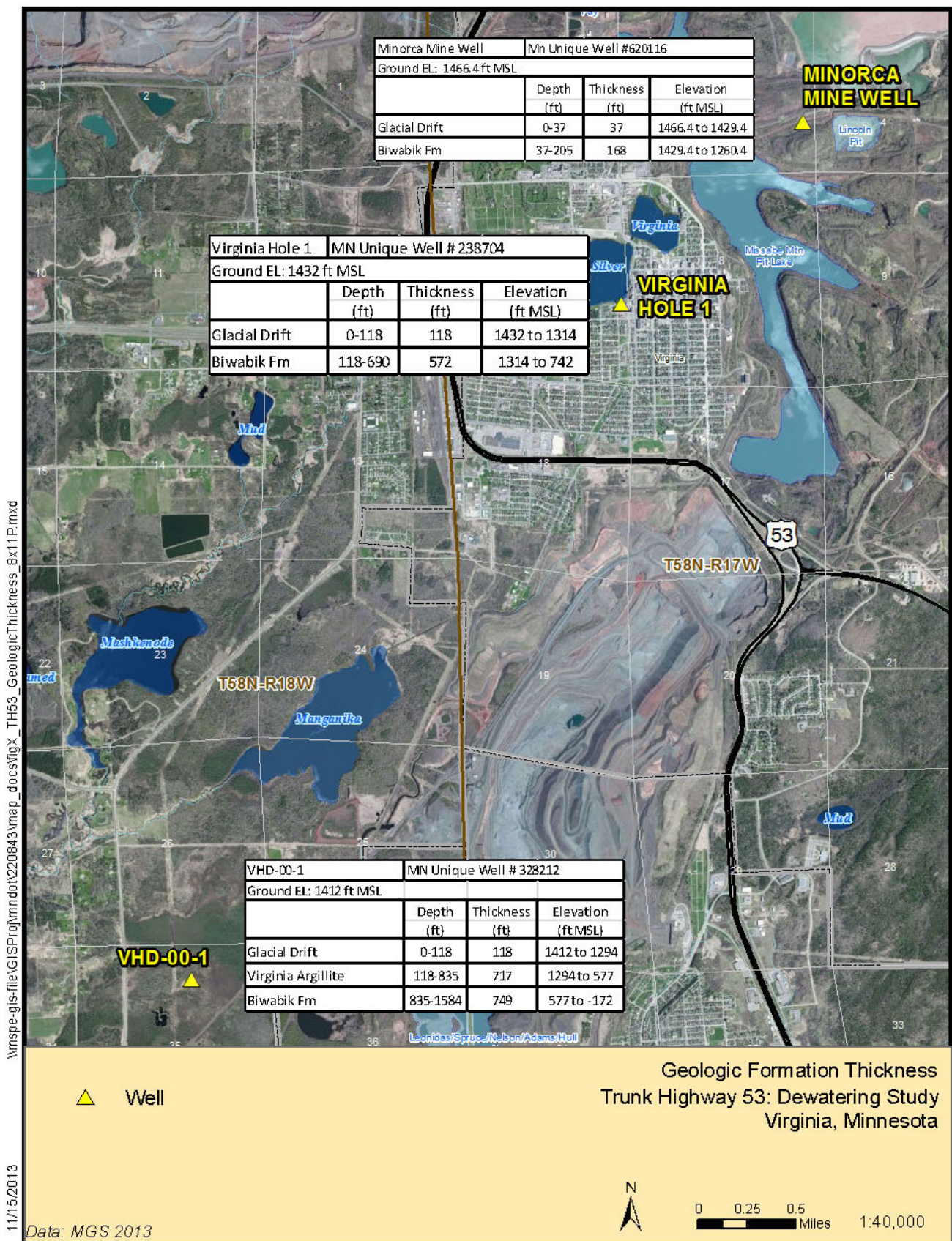


Figure 4 Geologic Formation Thickness Map

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11/18/2013

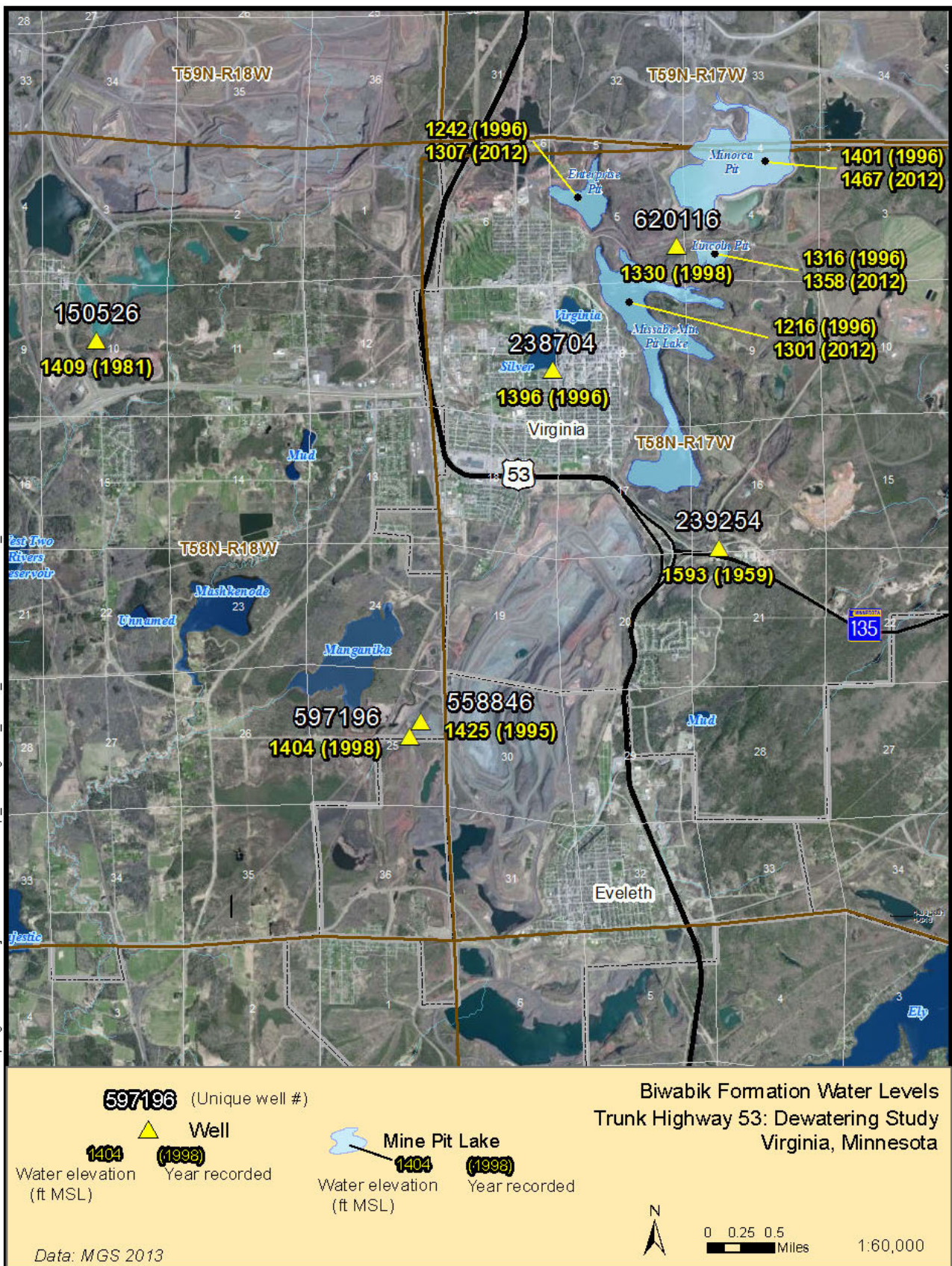


Figure 5 Biwabik Formation Water Levels

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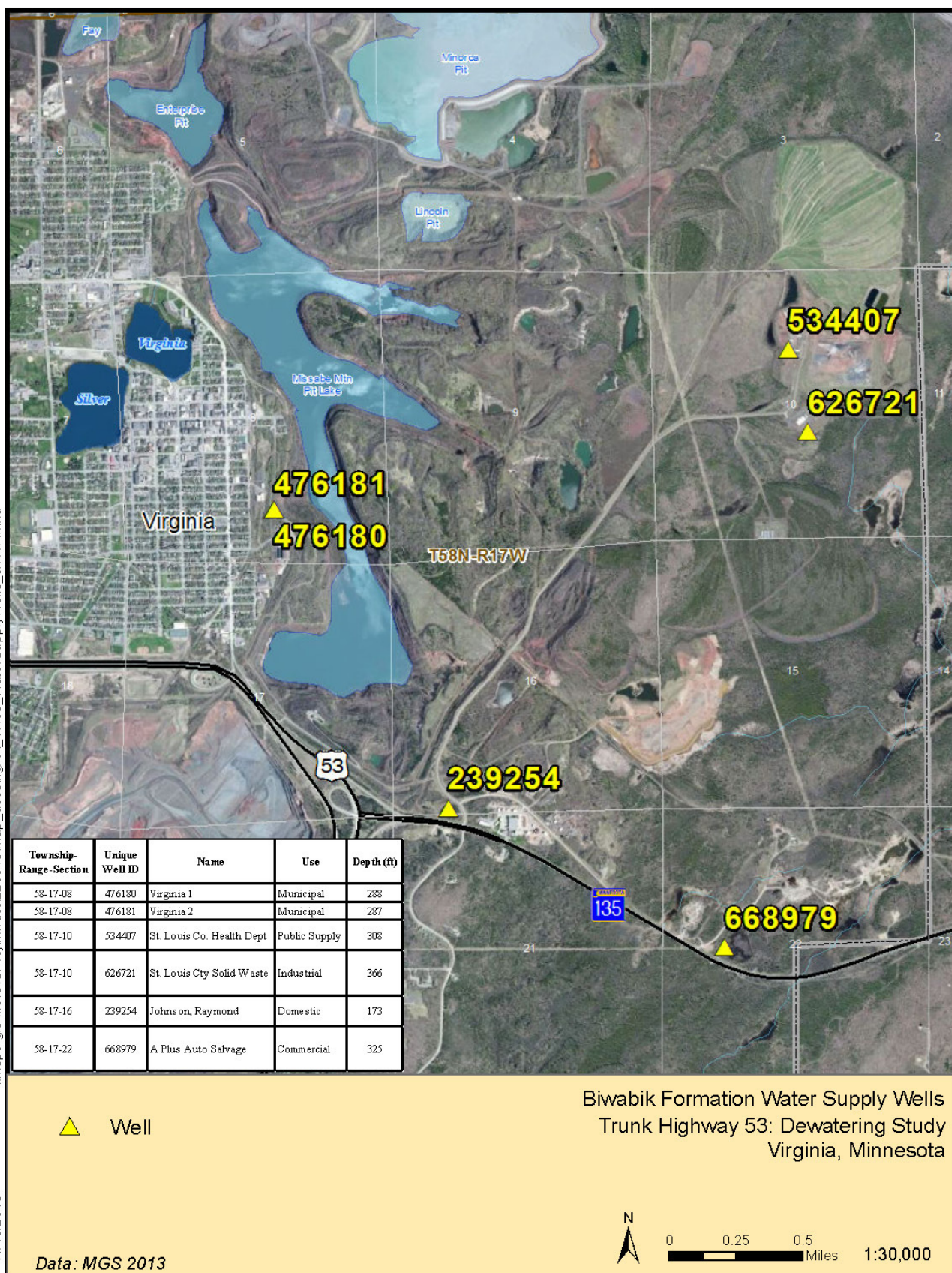


Figure 6 Biwabik Formation Water Supply Wells

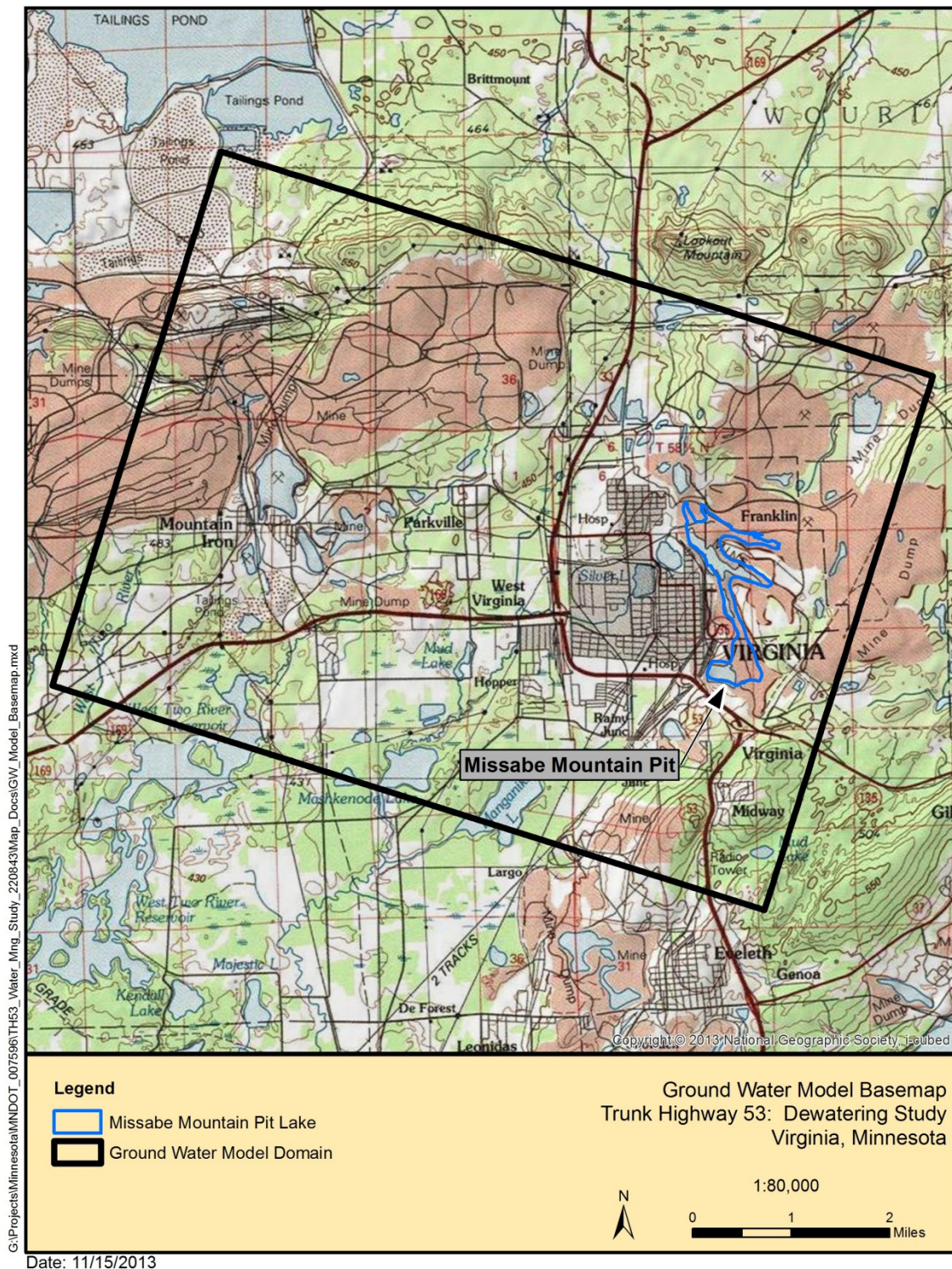


Figure 7 Model Domain and Grid Orientation

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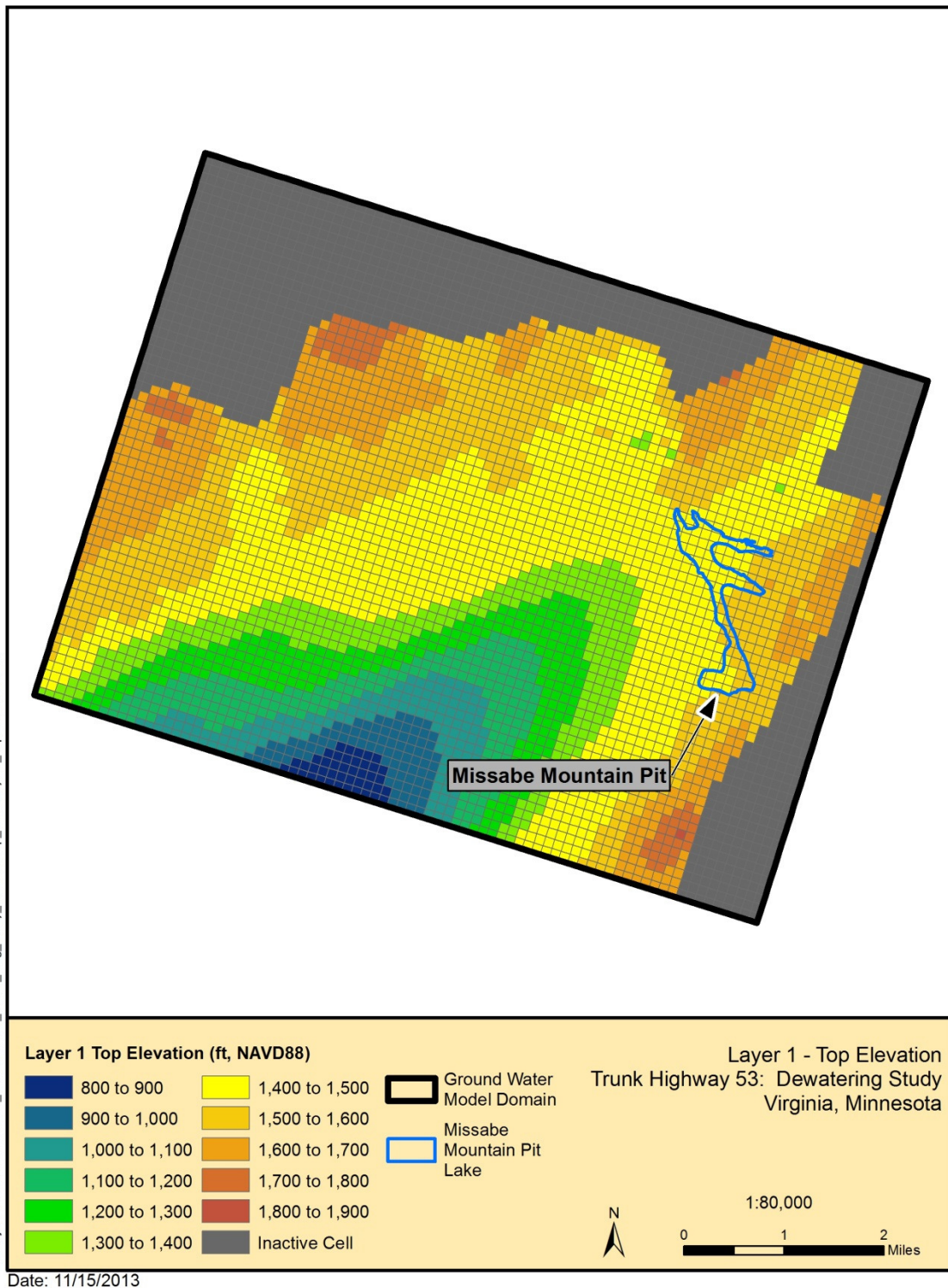


Figure 8 Model Grid and Elevation of Top of Layer 1

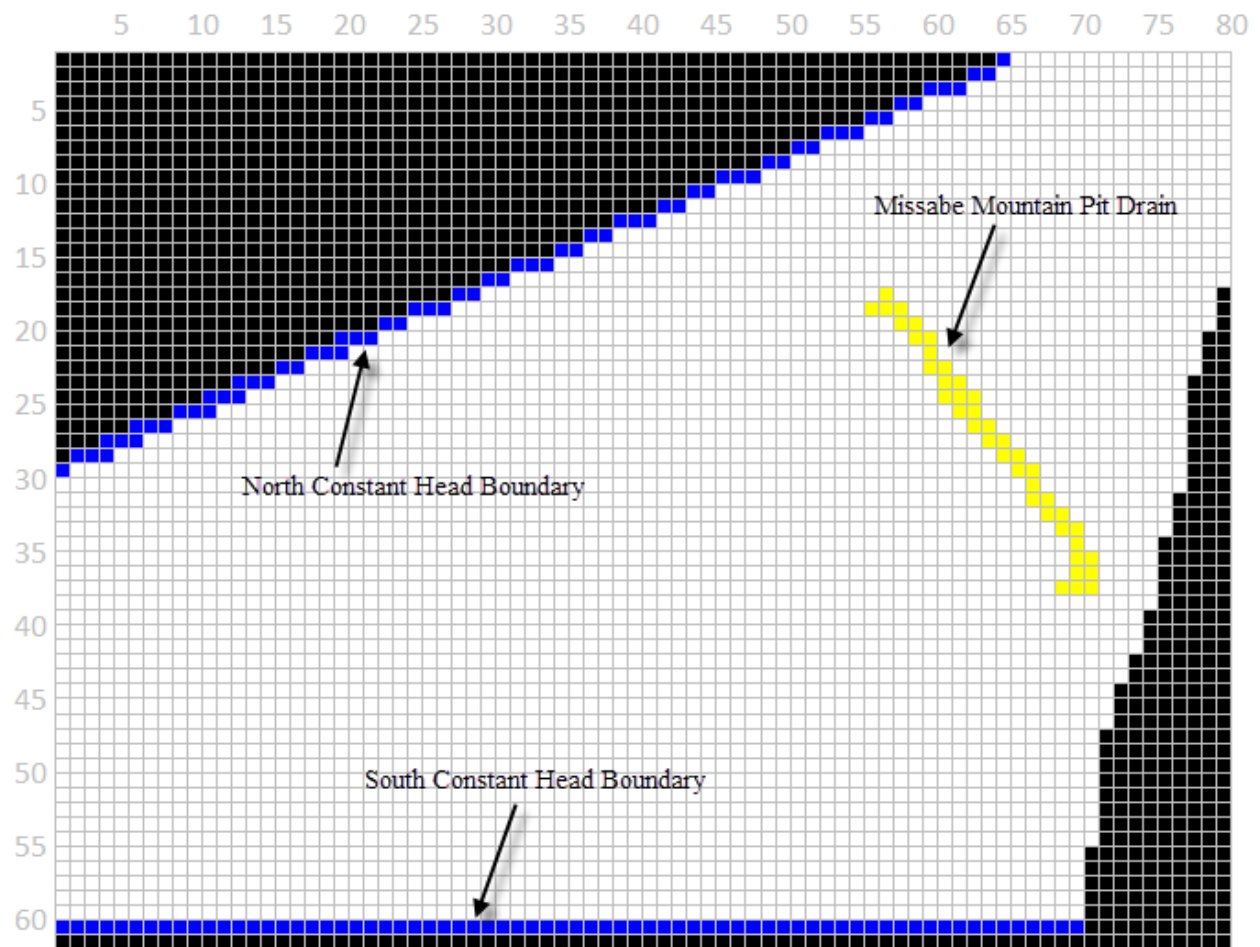


Figure 9 Model Boundaries

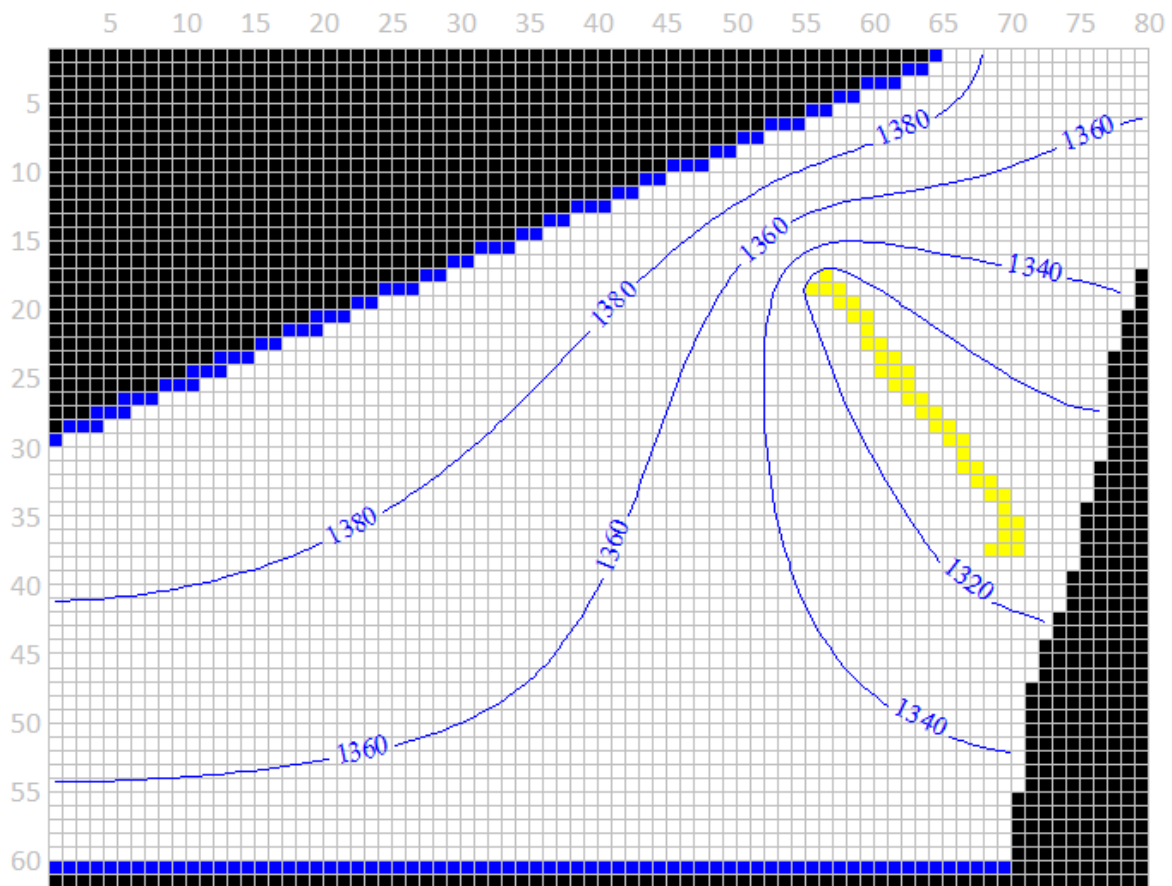


Figure 10 Modeled Steady-State Groundwater Elevation for Biwabik Formation

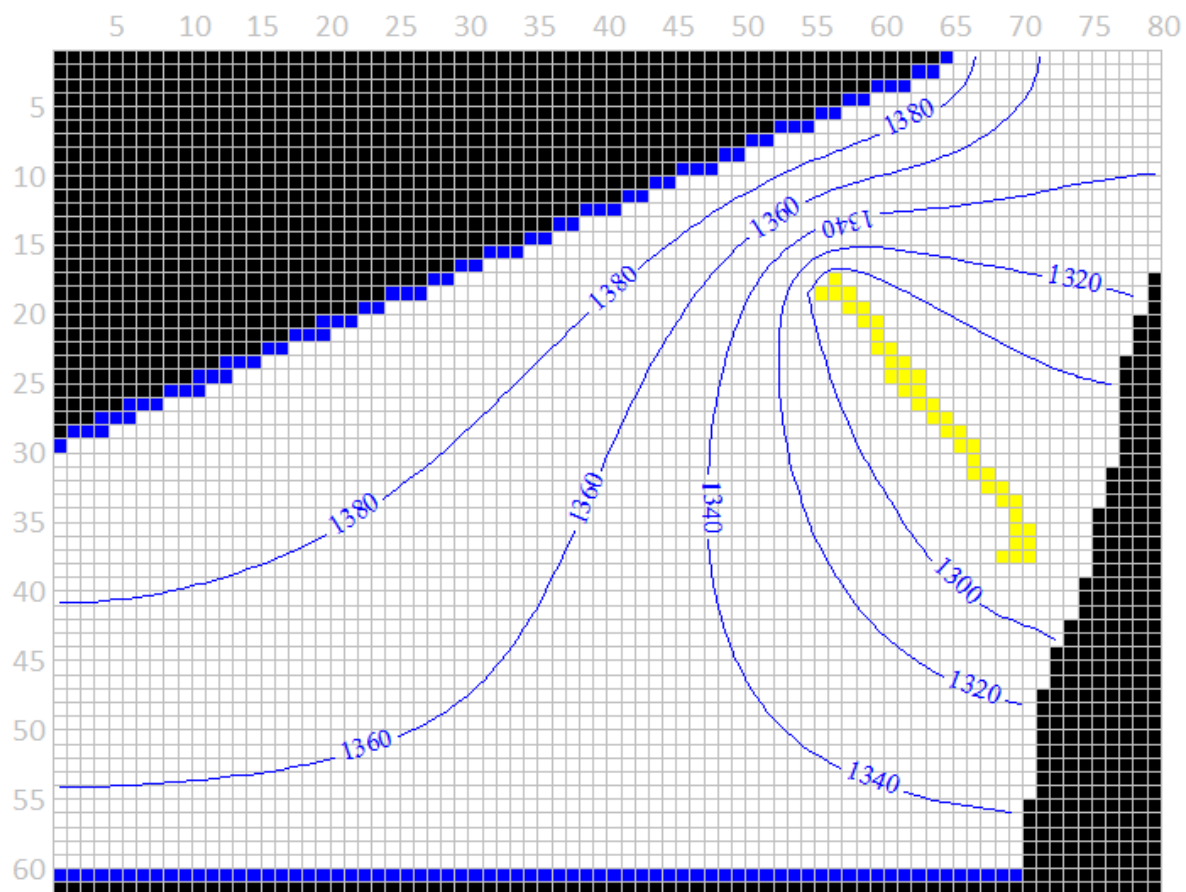
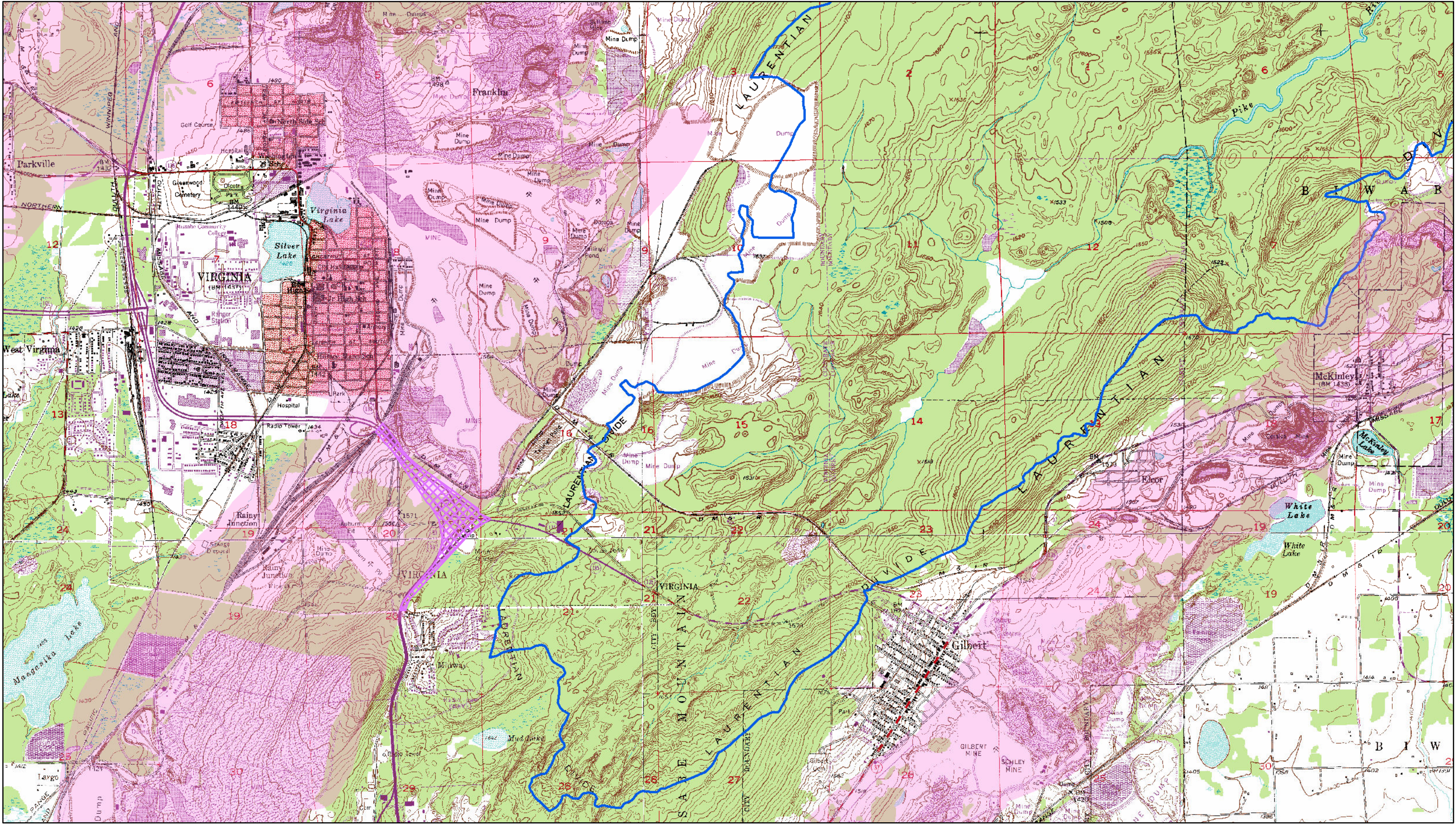


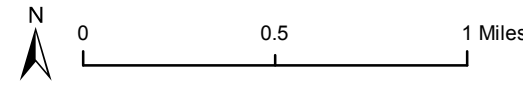
Figure 11 Modeled Groundwater Elevation for Biwabik Formation After 5 Years of Dewatering at Elevation 1,275 Feet



Source: DNR Watersheds - DNR Level 04 - HUC 08 - Majors



- Legend**
- Existing US 53 Easement Area
 - DNR Level 04 Watersheds
 - Biwabik Iron Formation





Memorandum

To: Roberta Dwyer, MNDOT

From: Beth Kunkel, Kimley-Horn

Date: September 12, 2013

Subject: US 53 Virginia to Eveleth: Summary of Existing Water Appropriation Permits and Intake Locations within Study Area

Dewatering information was obtained through email correspondence with Michael Crotteau, Mining Hydrologist at the Minnesota Department of Natural Resources, Division of Ecological & Water Resources. He provided information on permits held by United Taconite (UTAC), ArcelorMittal/Minorca, and the City of Virginia, as well as maps showing intake locations for the Thunderbird and Missabe Mountain Pits. According to the draft *Source Water Protection: Virginia Public Water Supply System* report (NTS, Inc., May 2013), as of October 2012 the elevation of the Missabe Mountain Pit Lake is 1,302 feet above mean seal level (AMSL). The permit information is summarized below, and the maps are attached.

ArcelorMittal/Minorca (see Exhibit 1)

Permit # 1973-5095

- Intake location:
 - Enterprise Pump (Installation #1), Enterprise Pit Lake, north of Missabe Mountain Pit Lake

Permit # 2008-0216

- Pumping rate not to exceed 2,000 gallons per minute (GPM)
- Minimum target elevation (so as not to interfere with City of Virginia's water supply) is 1,280 feet AMSL
- Intake location:
 - Missabe Mountain Pit Pump (Installation #1), northwest of Virginia
- Discharge location:
 - Missabe Mountain Pit Lake, north of Missabe Mountain Pit Pump (Installation #1)

UTAC Thunderbird Mine (see Exhibits 2 and 3)

Permit # 1975-2137

- Overall permit pumping rate limit of 11,623 GPM for all installations under this permit number (includes north and south areas of Thunderbird Pit)
- According to NPDES permit, combined discharge for Sump 5 and the proposed Sump 8 is 5.8 MGD (equating to just over 4,000 GPM)
- Current pumping elevation is 1,121 feet AMSL; next year pumping elevation is planned to be around 1,085 feet AMSL
- Intake locations (active locations only, see Exhibit 2):



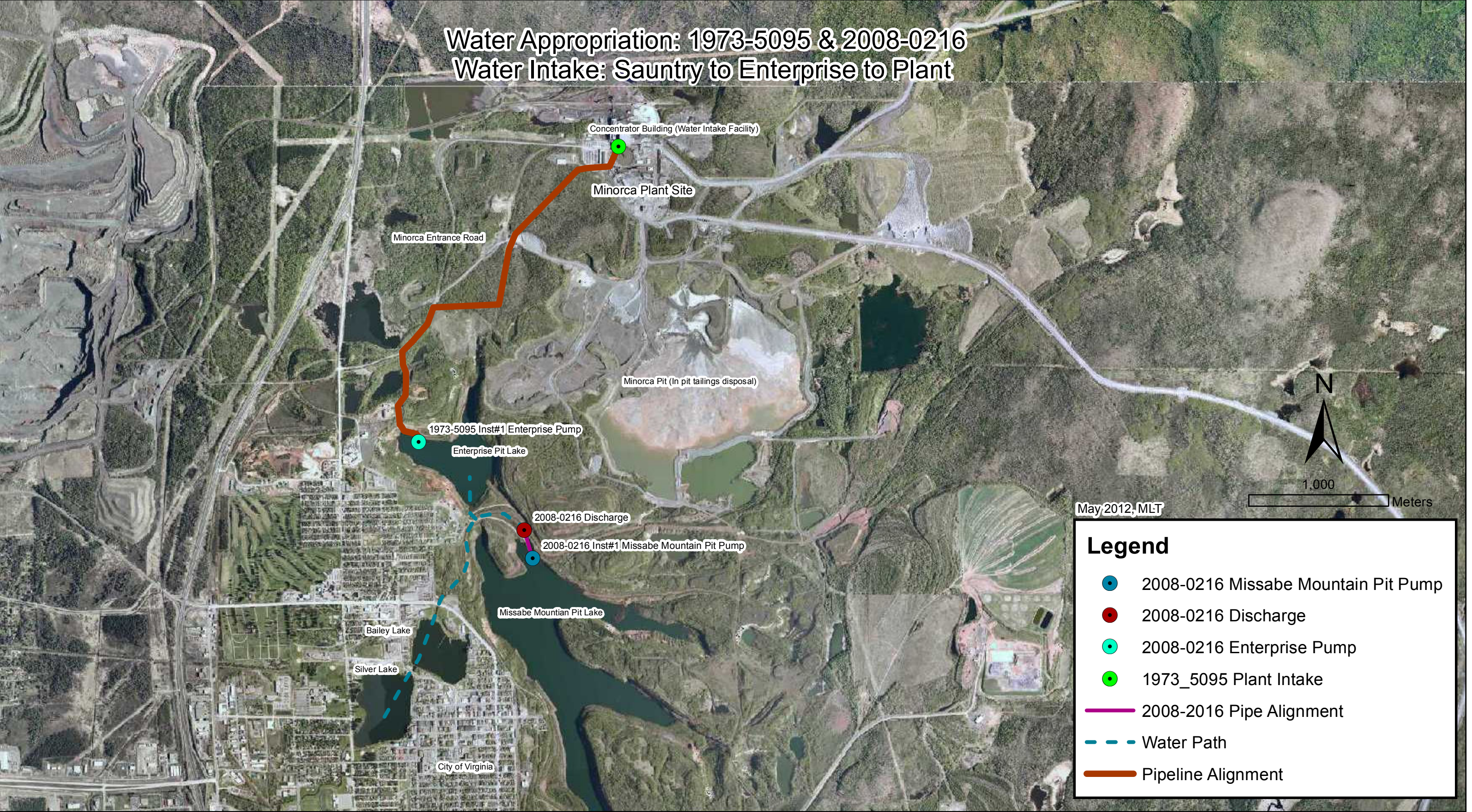
- Installation #5
 - Dewatering – Thunderbird
 - Pit dewatering to Manganika Creek via unnamed tributary
 - Pumping rate: 2,300 GPM
- Installation #6
 - Dewatering – Spruce Mine Shaft
 - Spruce mine shaft to Long Lake Creek via unnamed tributary
 - Pumping rate: 3,900 GPM
- Installation #2
 - Dewatering – Expansion
 - Pit dewatering to Long Lake Creek via unnamed tributary
 - Pumping rate: 5,000 GPM
- Installation #3
 - Dewatering – Spruce/Nelson (Gross Nelson)
 - Pit dewatering to stand pipe (road watering)
 - Pumping rate: 1,000 GPM
- Proposed dewatering installation (see Exhibit 3)
 - North Pit Sump (Proposed Pump Station #8)
 - No maximum pumping rate given in permit for when this sump is authorized
- MPCA NPDES Permit #MN0044946 – allows for discharge where pipelines converge in the Thunderbird Pit (see Exhibit 3)

City of Virginia

Permit # 1984-2037

- Pumping rate not to exceed 4,000 GPM (1 billion gallons per year)
- The City appropriates water out of the Missabe Mountain Pit for municipal water supply via two horizontally-drilled wells that extend to a mine drift, located on the west side of the pit and east side of town. The drift elevation is approximately 1,117 feet AMSL.
- Intake locations:
 - New Missabe Mountain Pump Station (NW ¼, SW ¼, NE ¼, Section 8, T58N, R17W)
 - West Well (No. 476180)
 - Pumping rate: 2,000 GPM
 - East Well (No. 476181)
 - Pumping rate: 2,000 GPM

Water Appropriation: 1973-5095 & 2008-0216
Water Intake: Sauntry to Enterprise to Plant



May 2012, MLT

Legend

- 2008-0216 Missabe Mountain Pit Pump
- 2008-0216 Discharge
- 2008-0216 Enterprise Pump
- 1973_5095 Plant Intake
- 2008-2016 Pipe Alignment
- - - Water Path
- Pipeline Alignment



Exhibit 2

Proposed North Pit Dewatering Installation and Pipeline

United Taconite DNR Water Appropriation Permit #75-2137

